Habitat and Biotic Conditions During 1995 in Streams Influenced by Wildfire

Prepared For:

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IDAHO STATE UNIVERSITY

3 July 1996

Dr. David Burns
Payette National Forest
McCall, Idaho 83638

Dear David,

Enclosed please find a copy of our report on the research we conducted in the Payette National Forest during 1995. This report includes data from both the Big Creek streams and the streams along the S.F. of the Salmon. If there are any corrections or changes that need to be made, please let me know within a month and I will revise the report. Currently, I have our trip to the S.F. Salmon area scheduled for the first week in August; hope to see you then. If you have any other questions feel free to call me (208) 236-2139 or Dr. Minshall (208) 236-2236.

Sincerely,

Todd V. Royer

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IDAHO STATE UNIVERSITY

Dr. David Burns
Payette National Forest
McCall, ID 83638

27 August 1996

Dear David,

I recently discovered an error in our 1996 report, "Habitat and Biotic Conditions During 1995 in Streams Influenced by Wildfire." In Figure 11 (page 27) invertebrate density was inadvertently plotted in the graph titled Taxa Richness. I have enclosed a corrected version of Figure 11. Sorry for the mistake.

Sincerely,

Todd Royer

Todd Royer

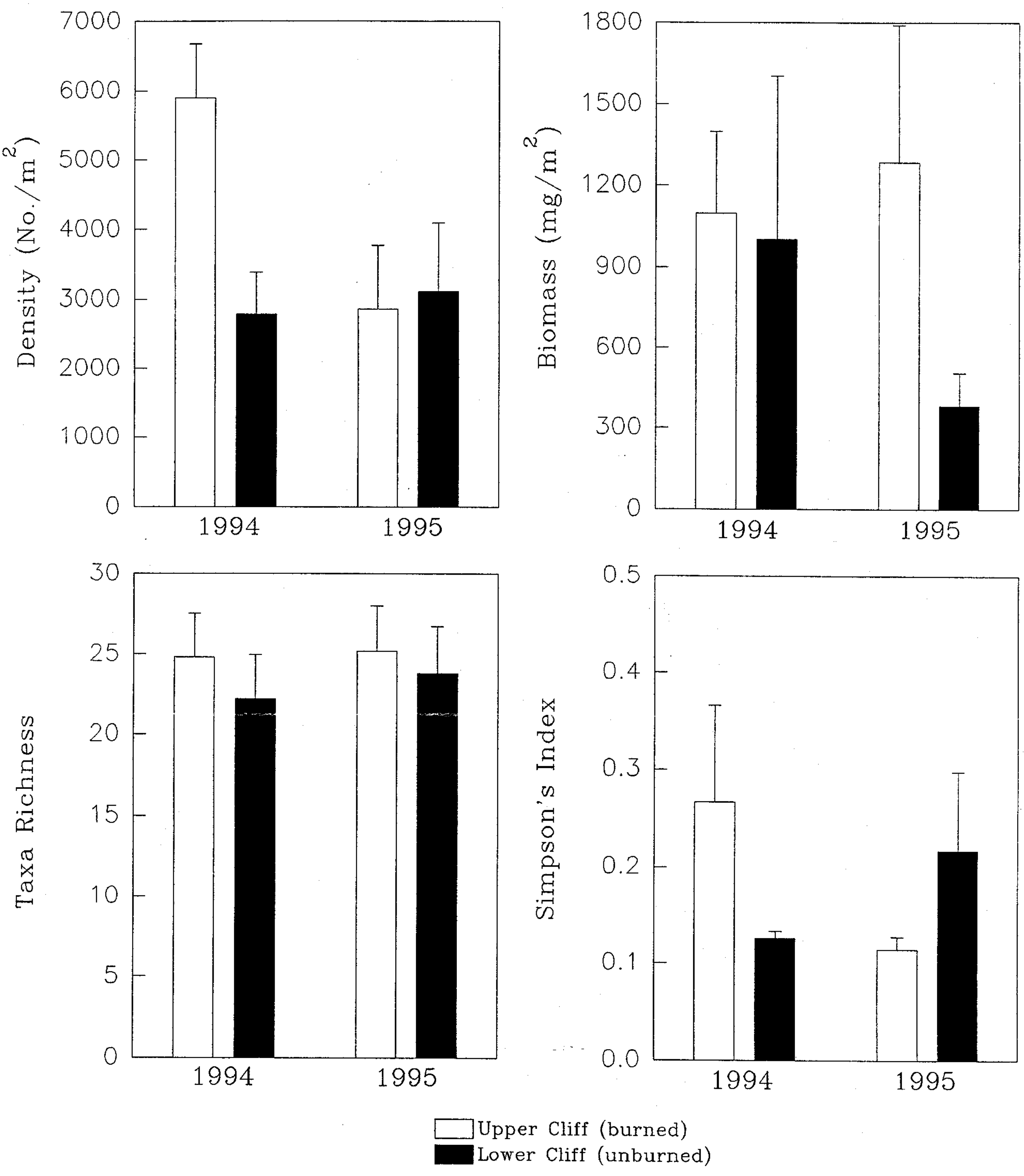

Fig. 11. Mean values of density, biomass, taxa richness, and Simpson's Index for the macroinvertebrate communities in Upper and Lower Cliff Creek during August 1994 and July 1995. Error bars equal +1SD from the mean, n=5.

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SUMMARY

We examined benthic habitat and invertebrate communities in several tributaries to Big Creek (within the Frank Church Wilderness Area) and to the South Fork of the Salmon River (adjacent to the wilderness area). Our goals were to provide baseline data for these streams and to measure possible effects from recent wildfires that occurred in the catchments of some of the streams we studied. In general, we observed no immediate effect of the Chicken Fire on the S.F. Salmon River tributaries, likely due to the patchy nature of the fire in the areas we examined. Likewise, we have not observed major changes in the channel or substrata characteristics in Big Creek tributaries burned by the 1988 Golden Fire, despite removal of the surrounding terrestrial vegetation. However, although only minor in-stream habitat changes have occurred in the burned systems to date, we hypothesize that the burned streams will be more severely influenced by increased discharge than will the reference streams. Both catchments experienced unusually high runoff during the spring of 1996, and we plan to examine the effect of the high flows on habitat and biotic variables following a return to baseflow conditions.

In the Big Creek tributaries, macroinvertebrate density and diversity appeared more temporally variable in the reference streams than in the burned streams. Richness ranged around approximately 20-30 taxa in the Big Creek streams, except for Goat Creek which had slightly lower richness. In the S.F. Salmon tributaries, only minor year-to-year variation was seen in taxa richness, although this observation is based on only two years of data. In general, invertebrate diversity appeared slightly lower in the S.F. Salmon sites than in the Big Creek sites (approx. 5-10 fewer taxa). Taxa richness in both catchments was similar to that in streams along the Middle Fork of the Salmon River and to streams in Yellowstone National Park.

Measurement of CPOM retention, using plastic leaf analogs, indicated greater retention in the burned portion of Cliff Creek than in the unburned portion. This reflects the fact that trees, which were killed by the fire but initially left standing, have begun to enter the stream channel. Thus, salvage logging, which removes the dead, standing trees, may slow recovery of stream ecosystems from wildfire, at least in terms of channel stability and CPOM retention. Functional measures clearly are needed to fully understand the effects of disturbances on stream ecosystems. Future monitoring should include functional, as well as structural, parameters and possibly seasonal measurement of those parameters which are expected to display strong seasonal variation.

INTRODUCTION

Our primary research goal during 1995 was to continue monitoring tributaries to Big Creek and the South Fork of the Salmon River (S.F. Salmon) that we had examined in previous years. These streams were examined as part of an on-going effort to study the immediate and long-term effects of wildfire on stream ecosystems in the Payette National Forest (see Royer et al. 1995). The studies in the Big Creek catchment were designed to examine the influence of the 1988 Golden Fire, while those in the S.F. Salmon catchment examined the 1994 Chicken Fire.

Along with routine biomonitoring, we also measured coarse particulate organic matter (CPOM) retention in the burned and unburned reaches of Cliff Creek. Retention of CPOM is an important functional characteristic in stream ecosystems. CPOM is the primary energy source for most forested, mountain streams such as Cliff Creek. Wildfire is thought to alter CPOM retention capabilities by changing channel morphology and woody debris (a major CPOM retention device) inputs. Although limited in scope, this experiment was a first attempt to incorporate such functional measures in our examination of wildfire effects on streams of the Frank Church Wilderness Area.

For all streams examined, the results provide baseline habitat and macroinvertebrate data against which the effects of future disturbances (natural or anthropogenic) can be measured. For example, small temperature dataloggers were used to obtain a complete annual thermograph for two representative streams: Rush and Pioneer Creeks. These data can now be used to document the influence of disturbances that may alter riparian shading and subsequently change thermal conditions in the streams (e.g., wildfire or insect outbreak). The experimental timber harvest, scheduled for autumn 1996, in the catchment of Tailholt Creek (USFS 1995) is another example of the usefulness of base-line data; given the data collected to date, biological effects from the logging can be examined.

STUDY SITE DESCRIPTIONS

The study streams were located within the Payette National Forest in central Idaho either (1) along Big Creek in the Frank Church 'River of No Return' Wilderness Area or (2) along the South Fork of the Salmon River just outside the wilderness area (Table 1). In both catchments, the streams flow through steep valleys with forested slopes of primarily Douglas Fir and Ponderosa Pine and extensive areas of bare rock. Open areas of grass and sagebrush are common on the drier slopes in both catchments. The majority of the annual precipitation occurs as snow, resulting in peak flows during spring and early summer. The streams generally remain at baseflow conditions from mid-summer through autumn.

Study streams in the Big Creek catchment were influenced, to varying degrees, by either the Golden Fire of 1988 or the Rush Point Fire of 1991. The upper portions of the Cliff and Cougar were affected by the Golden Fire; Goat Creek was not burned by the wildfire, but rather by an intentional 'back-burn' used to slow the progress of the wildfire. Cave Creek serves as a reference for these sites. All of the above streams have a southern aspect. The upper portion of the Rush and Pioneer Creek catchments were minimally influenced by the Rush Point Fire and have northern aspects. Thus they provide a comparison with the south-facing streams listed above. In the S.F. Salmon catchment, Pidgeon and Fritser Creek were moderately burned during the Chicken Fire of 1994. Tailholt and Circle End were not affected by the Chicken Fire. All of the S.F. Salmon tributaries we examined had a southeastern aspect.

METHODS

General field methods used for the various segments of this

Table 1. Location of the study streams in the Big Creek and S.F. Salmon catchments.

Stream	Elevation (m)	Longitude	Latitude	Township	Range
Big Creek Catchment					
Rush Cr.	1170	114 51'W	45 07'N	T20N	R13E
Pioneer Cr.	1170	114 51'W	45 06'N	T20N	R13E
Cave Cr.	1220	114 57'W	45 08'N	T21N	R12E
Cabin Cr.	1300	114 56'W	45 09'N	T21N	R12E
Cliff Cr. (upper)	1680	114 51'W	45 08'N	T20N	R13E
Cliff Cr. (lower)	1200	114 51'W	45 07'N	T20N	R13E
Goat Cr.	1130	114 48'W	45 07'N	T20N	R13E
Cougar Cr.	1100	114 49'W	45 07'N	T20N	R13E
S.F. Salmon Catchment					
Circle End Cr.	1110	115 40'W	45 02'N	T20N	R06E
Tailholt Cr.	1110	115 40'W	45 02'N	T20N	R06E
Pidgeon Cr.	1110	115 38'W	45 04'N	T20N	R07E
Fritser Cr.	1100	115 37'W	45 05'N	T20N	R07E

study are summarized in Table 2. The methods were consistent with methods used in our previous studies of wildfire and wilderness streams. These are relatively routine in stream ecology and are described in detail in standard reference sources (Weber 1973, Greeson et al. 1977, Lind 1979, Stednik 1991, Merritt and Cummins 1996, APHA 1992) or in more specific references listed in Table 2. Mean substratum size, water depths, and near-bed water velocities were determined at 100 random locations along a substantial (ca. 200 meter) reach of stream. Methods for sampling macroinvertebrates are described in Platts et al. (1983). Procedures for sample analysis are described briefly in Table 2.

Density, biomass, taxa richness, and Simpson's Index were determined for all sites and years. In addition, rapid bioassessment metrics (Robinson and Minshall 1995) and principal components analysis (PCA) were used to examine the macroinvertebrate communities of the Big Creek sites from 1993-95. The invertebrate metrics included: density, biomass, taxa richness, Ephemeroptera-Plecoptera-Trichoptera (EPT) richness, %EPT, Simpson's Index, %dominance, %Oligochaeta, %Chironomidae, %filterers, and %scrapers. A similar analysis is planned for the data from the S.F. Salmon sites, and for the complete Big Creek data set, and will be reported on in the future.

The measurement of CPOM retention in Cliff Creek was conducted by releasing 100 leaf analogs into the upstream end of a 100 m reach (Speaker et al. 1988). The leaf analogs were pieces of biodegradable surveyor's flagging 3 cm wide by approximately 6 cm long and brightly colored to aid in recovery. All 100 analogs were released individually over a 2-3 minute time period and immediately upstream of a mixing zone. A block-net was situated at the downstream end of the reach to quantify the number of analogs transported through the study reach. Approximately 2.5 hours after the release, the analogs were collected, beginning at the block-net and working upstream. The

Table 2. Summary of variables, sampling methods, and analytical procedures used in the study.

Variable	Type*	Sampling Method	Analytical Method	Reference
A. Physical				
Temperature	P	Continuous measurement with a datalogger	Calculate temp. indices	
Substratum Size	R	Measure x-axis of 100 randomly selected substrata	Calculate mean substratum size	Leopold 1970, Bevenger and King 1995
Substratum Embed-dedness	R	Visual estimation on 100 randomly selected substrata	Calculate mean substratum embededdness	Platts et al. 1983
Stream Width	T	Measure bank-full width using a nylon meter tape, n=5	Calculate mean stream width	Buchanan and Somers 1969
Stream Depth	R	Measure water depth at the 100 randomly choosen substrata	Calculate mean water depth	
Discharge	T	Velocity/depth profile Velocity measured with a small C-1 Ott meter	Q=WxDxV; where Q=discharge, W=width, D=depth, and V=vel	Bovee and Milhous 1978
B. Chemical				
Conductivity	P	Field measurement of single grab sample from each site	Temperature comp-ensated meter (Orion model 126)	APHA 1992 Stednik 1991

* P=point measure; T=transect across stream; R=random throughout a defined reach.

Table 2 (cont.).

Variable	Type*	Sampling Method	Analytical Method	Reference
pH	P	Field measurement	Digital meter (Schott model CG837)	APHA 1992 Stednik 1991
Alkalinity	P	Single grab sample	Methly-purple titration	APHA 1992 Stednik 1991
Hardness	P	Single grab sample	EDTA titration	APHA 1992 Stednik 1991
C. Biological				
Invertebrates	R	Collect 5 samples using a Surber sampler with 250μm mesh	Remove invertebrates, identify, enumerate, and analyze community properties	Platts et al. 1983, Merritt and Cummins 1996
Periphyton	R	Collect samples from 5 individual substrata	Methanol extraction for chlorophyll a and measurement of AFDM	Robinson and Minshall 1986
Diatoms	R	Collect samples from 5 individual substrata	Identify to species	St. Clair and Rushforth 1976, Robinson et al. 1994
Benthic Organic Matter	R	Recover from Surber samples	Determine AFDM (3 hr @ 550 °C)	

* P=point measure; T=transect across stream; R=random throughout a defined reach.

distance traveled and the type of retention device (e.g., woody debris, cobble, etc.) were recorded.

RESULTS

Big Creek Tributaries

In general, relatively minor year to year variation has been observed in the physical and chemical parameters measured (Table 3). This should provide a solid base for evaluating the effects of future disturbances on these streams. Within each stream, measures of benthic habitat heterogeneity also have displayed relatively little annual variation (Table 4). The exception may be an increase in substrate embeddedness in Cliff and Goat Creeks, which have both increased from approx. 40% in 1993 to approx. 65% in 1995. Thermal conditions, measured from May 1994 through May 1995, were distinctly different between Pioneer and Rush Creeks. Both maximum and minimum temperatures were consistently greater in 6th order Rush Creek than in 2nd order Pioneer during all seasons except winter (Fig. 1). The annual range in temperature was 20°C in Rush and 12°C in Pioneer.

Mean daily temperatures (MDT) were used to calculate cumulative degree days. Again, Rush was notably warmer than Pioneer (Fig. 2). The greatest difference in MDT occurred from June through October, when Rush was as much as 6°C warmer than Pioneer. Figure 3 shows the cumulative relative frequency of MDT in the two streams. All MDT in Pioneer were $\leq$11°C, while in Rush 20% of the MDT were $\geq$11°C (Fig. 3). Both streams have similar aspects, thus it is likely the larger size and more open canopy of Rush Creek is responsible for the warmer thermal conditions in that stream. We currently have dataloggers in Upper Cliff, Cliff, Pioneer, Rush, and Cougar Creeks and data from these streams will be presented in the future.

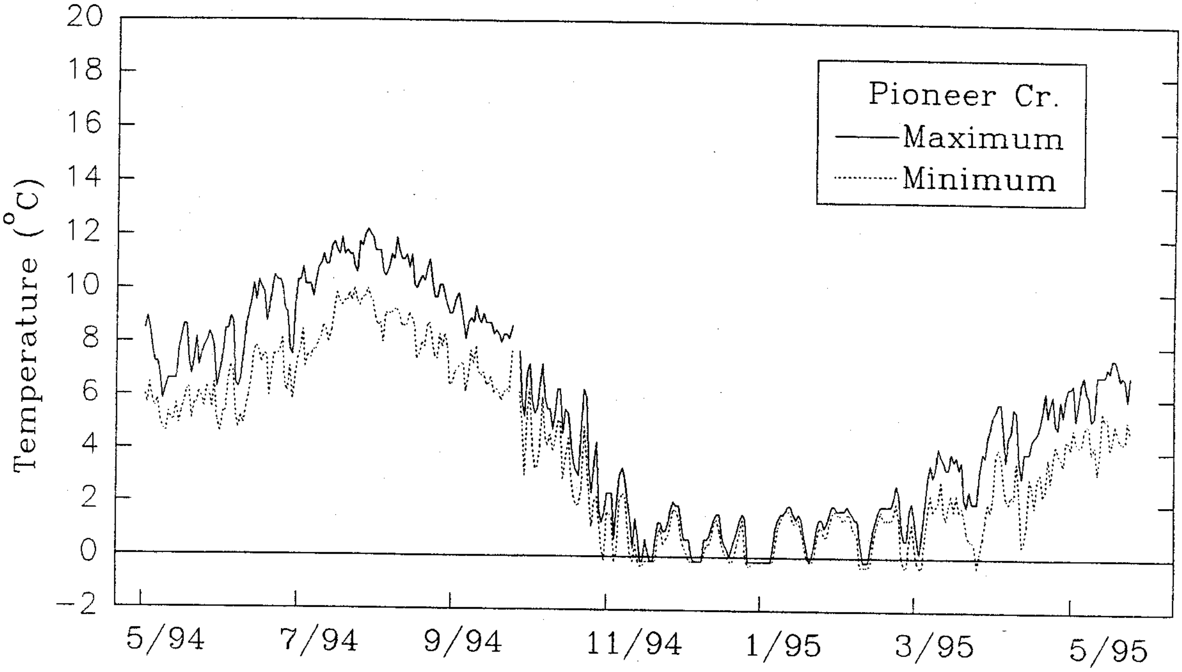
Mean values of benthic organic matter (BOM) measured during

Table 3. Discharge and various chemical measures for study streams.

Stream	Year	Discharge (m3/s)	Alkalinity (mg CaCO3/L)	Hardness (mg CaCO3/L)	Conductance (uS/cm @ 20C)	pH
Rush	1988	1.61	36	30	110	7.8
	1991				103	8.2
	1992	1.10	46	46	95	8.4
	1993	0.31				7.9
	1994	1.56			77	
	1995	1.75	32	57	76	8.2
Pioneer	1990	0.16	62	86	88	8.1
	1991	0.01			125	8.0
	1993	0.02	26	48	72	
	1994	0.17			113	
	1995	0.21	42	81	135	7.9
Cave	1990	0.31	24	44	39	7.9
	1993	0.08	19	24	55	
	1994	0.21				
	1995	0.17	20	40	48	8.1
Cliff	1990	0.32	35	66	61	8.2
	1991	0.18	77	71	73	8.2
	1992	0.08	48	49	99	8.0
	1993	0.09	26	44	77	7.7
	1994	0.10			79	
	1995	0.15	34	53	93	8.2
Goat	1990	0.01	86	110	139	8.1
	1991	0.09	49	51	153	8.4
	1992	0.01	80	76	151	8.2
	1993	0.01	41	68	116	8.1
	1994	0.01			148	
	1995	0.01	56	93	140	8.1
Cougar	1990	0.11	46	71	70	8.5
	1991	0.10	36	32	93	7.4
	1992	0.01	59	60	113	8.2
	1993	0.02	33	48	94	7.7
	1994	0.08				
	1995	0.10	48	85	107	8.2

Table 4. Habitat heterogeneity measures for study streams in the Big Creek catchment. SD = standard deviation, CV = coefficient of variation.

		Substrate Size (cm)			Substrate Embeddedness (%)			Bankfull Width (m)		Baseflow Depth (cm)	
Stream	Year	mean (n=100)	SD	CV	mean (n=100)	SD	CV	mean (n=5)	SD	mean (n=100)	SD
Rush	1988	14.6	14.0	0.96				15.1		35.0	10.0
	1992	13.3	9.2	0.69	18.8	26.7	0.96	12.0		21.0	10.0
	1993	21.3	14.8	0.69	35.0	28.9	0.51	13.4	1.5	26.2	7.3
	1994	13.9	13.2	0.95	39.3	34.0	0.46	6.3	4.8	26.2	7.9
	1995	22.6	16.7	0.74	25.0	26.2	1.05	11.8	0.6	35.0	10.3
Pioneer	1990	16.7	14.0	0.84	12.5	23.9	1.44	3.4		16.0	4.5
	1993	19.5	18.7	0.96	33.8	28.8	0.53	2.9	0.9	15.3	7.7
	1994	13.9	15.2	1.09	34.3	33.7	0.53	1.7	4.2	18.0	7.9
	1995	15.2	17.4	1.14	45.3	36.3	0.80	3.0	0.6	17.5	10.1
Cave	1990	18.8	12.2	0.65				6.1		15.0	6.0
	1993	18.2	17.0	0.93	59.8	29.8	0.30	5.4	0.5	15.3	8.1
	1994	18.3	15.9	0.87	45.0	33.9	0.40	4.1	8.1	15.6	9.5
	1995	15.1	18.7	1.24	56.5	33.1	0.59	5.2	1.2	18.8	7.9
Cliff	1990	25.3	17.7	0.70				3.5		20.0	4.0
	1991	22.5	20.3	0.90				3.8		20.0	8.0
	1992	26.8	26.8	1.00				5.5		20.0	14.0
	1993	21.5	16.8	0.78	41.8	31.6	0.43	3.2	0.7	16.4	8.3
	1994	19.5	16.3	0.84	40.9	30.8	0.44	2.0	6.4	20.9	10.2
	1995	21.5	24.4	1.13	66.0	73.4	1.11	3.5	0.7	22.1	10.7
Goat	1990	9.7	16.5	1.70				0.9		10.0	2.0
	1991	10.9	16.4	1.50				0.9		10.0	3.0
	1992	13.1	17.0	1.30				0.8		10.0	7.0
	1993	17.5	16.6	0.95	43.8	35.4	0.41	1.1	0.3	12.0	4.1
	1994	11.7	16.1	1.38	68.5	31.1	0.26	0.9	0.2	10.4	4.4
	1995	12.0	14.0	1.16	65.3	34.5	0.53	1.2	0.3	10.8	5.7
Cougar	1990	21.6	13.0	0.60				2.7		20.0	
	1991	22.6	27.1	1.20				3.1		20.0	6.0
	1992	13.0	14.3	1.10				2.6		20.0	20.0
	1993	21.1	20.9	0.99	42.5	30.5	0.42	2.5	0.9	16.3	8.1
	1994	15.5	11.9	0.77	50.3	33.8	0.36	1.6	0.7	18.8	10.3
	1995	19.2	17.1	0.89	47.5	31.5	0.66	2.5	0.6	20.3	11.3



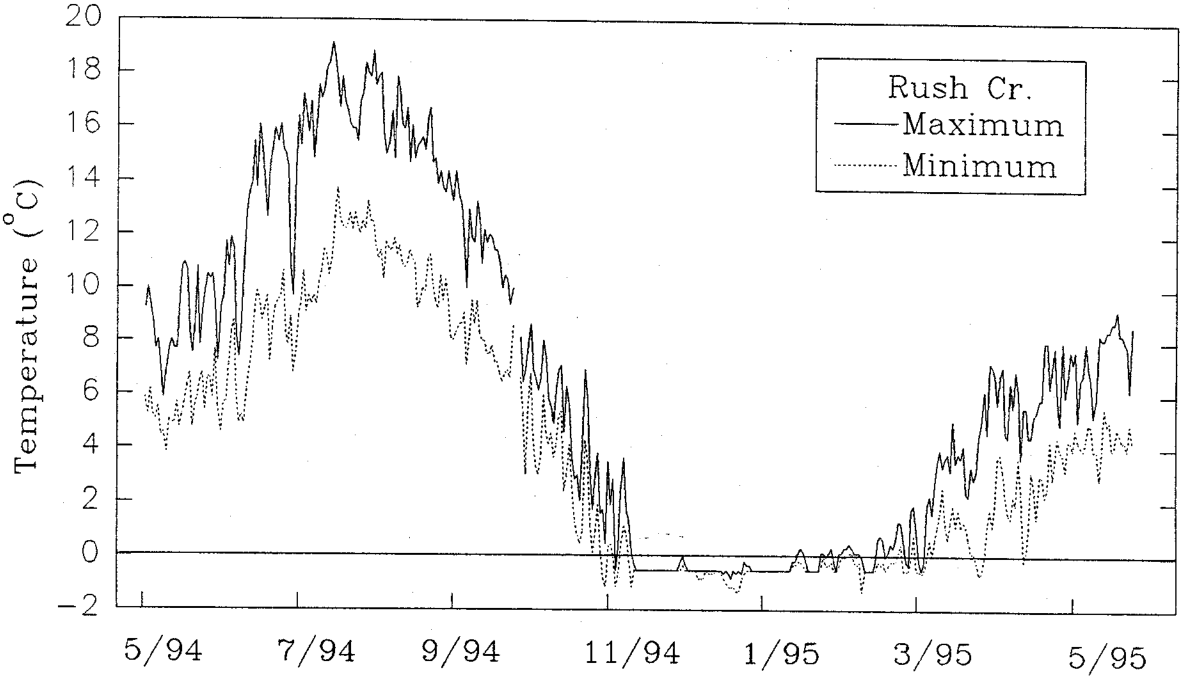


Fig. 1. Maximum and minimum water temperatures in Pioneer (upper graph) and Rush (lower graph) Creeks from May 1994–May 1995.

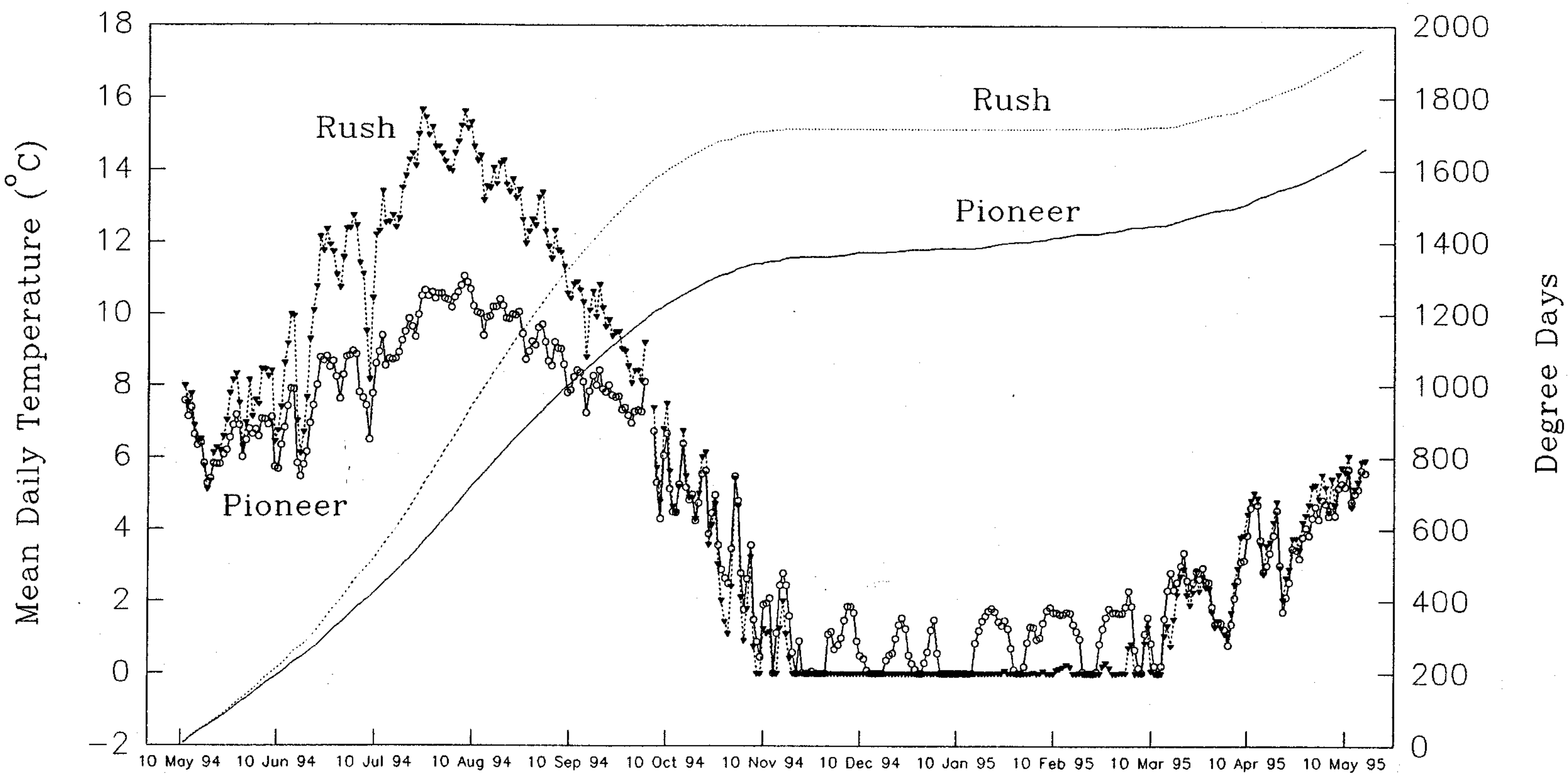


Fig. 2. Mean daily water temperature and cumulative degree days in Pioneer and Rush Creeks from May 1994 – May 1995.

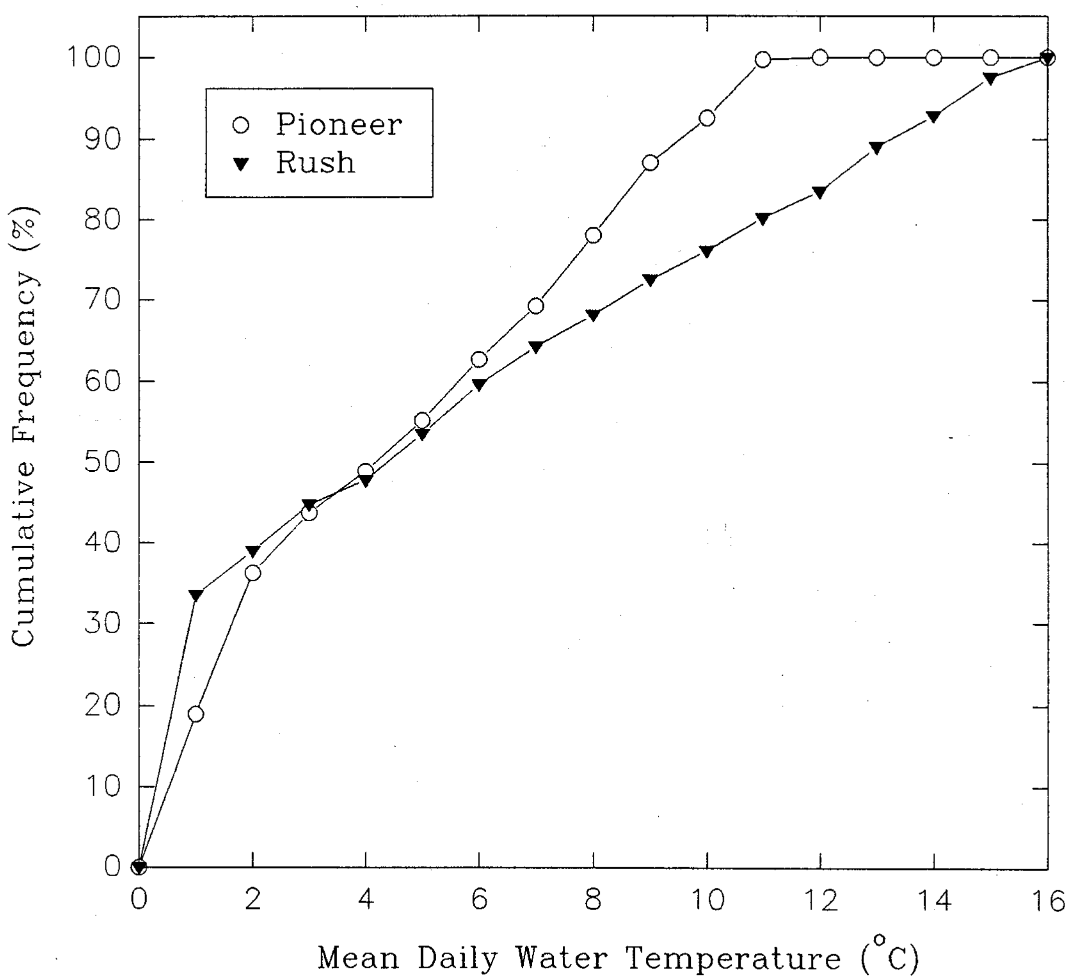


Fig. 3. Cumulative frequency of mean daily water temperatures in Pioneer and Rush Creeks. Graph based on data from May 1994 through May 1995.

1995 were similar to those observed in previous years for Rush, Pioneer, Cave, and Cliff Creeks (Fig. 4). Goat Creek displayed a BOM value similar to that of 1994, but reduced from 1990-1992. The BOM value in Cougar Creek was similar to the value obtained in 1990 and greater than those seen in 1991-1994. However, in both 1990 and 1995 the variation in BOM was quite large in Cougar Creek.

For all streams, the mean values of periphyton chl *a* obtained in 1995 were similar to values from 1994; all were less than 20 mg/m^2. During 1995, periphyton chl *a* was similar among Rush, Pioneer, Cave, and Cliff Creeks. Mean periphyton ash-free dry mass (AFDM) was more variable between streams than was chl *a* (Fig. 5). With the exception of Goat Creek, all streams displayed greater AFDM in 1995 than in 1994. Within 1995, AFDM was approximately twice as great in Rush than in Pioneer, Cave, or Cliff.

Mean density of aquatic macroinvertebrates measured in 1995 was lower in all streams, compared to values from 1994 (Fig. 6). The reduction was greatest in Pioneer Creek, were density in 1995 was approximately 50% of the 1994 value. The greatest densities in 1995 were observed in Cliff and Rush at approximately 5,000 individuals/m^2. Biomass displayed a trend similar to that of density in Rush, Pioneer, Cave, and Cliff Creeks. Biomass in Goat and Cougar during 1995 was slightly elevated from 1994, although the variance in 1995 was large. Mean biomass was greatest in Rush Creek, however the value was only 900 mg/m^2. Rush, Pioneer, Cave, and Cliff Creeks all exhibited mean biomass values in 1995 that were reduced by >50% from values observed in 1994 (Fig. 6).

Macroinvertebrate taxa richness and Simpson's Index did not exhibit the dramatic reductions seen in density and biomass. In fact, taxa richness was unchanged from 1994 to 1995 in Rush Creek, and similar or only slightly reduced from previous years

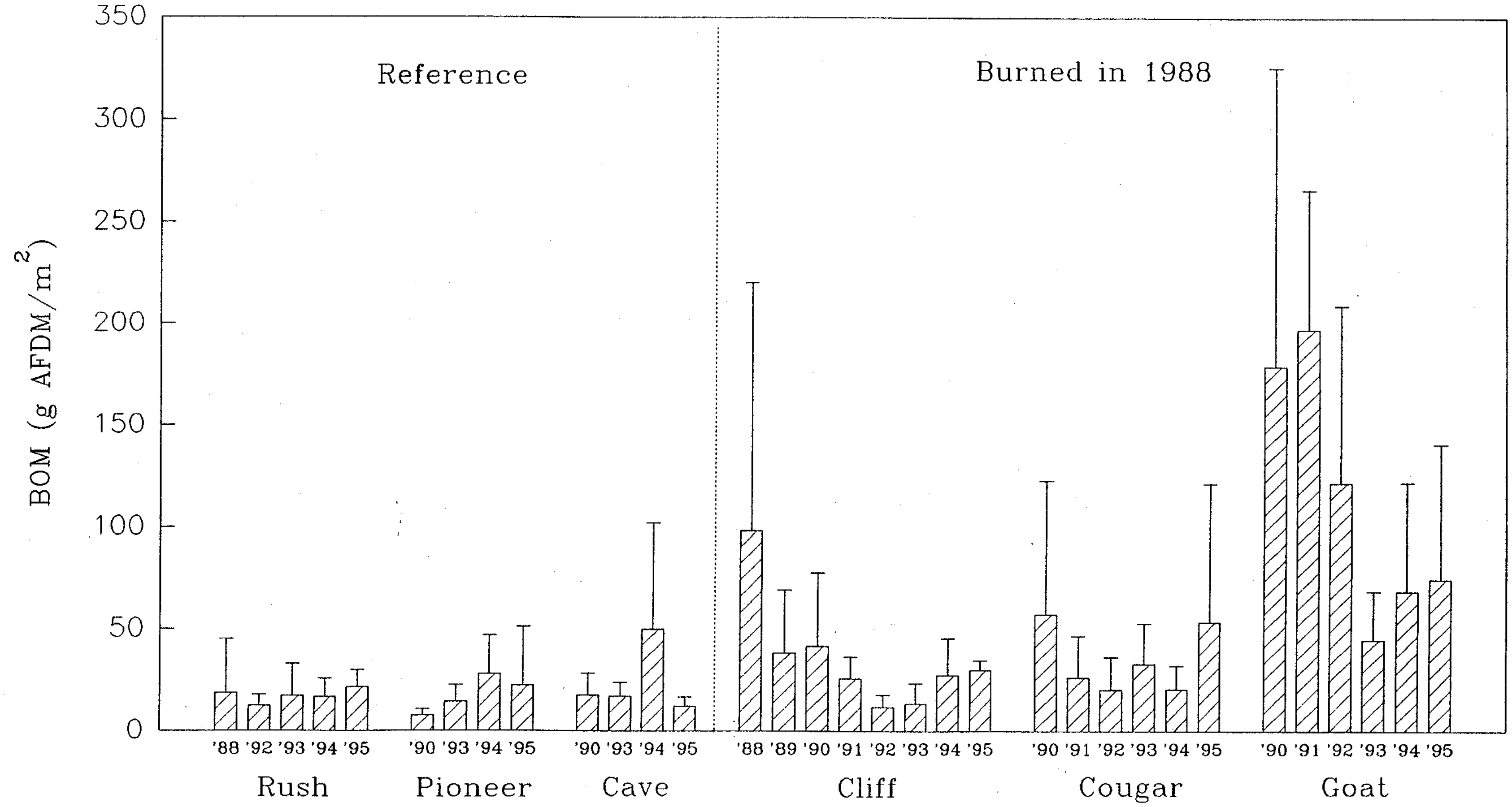


Fig. 4. Mean values of benthic organic matter (BOM) for the study streams. Error bars equal +1SD from the mean, n=5.

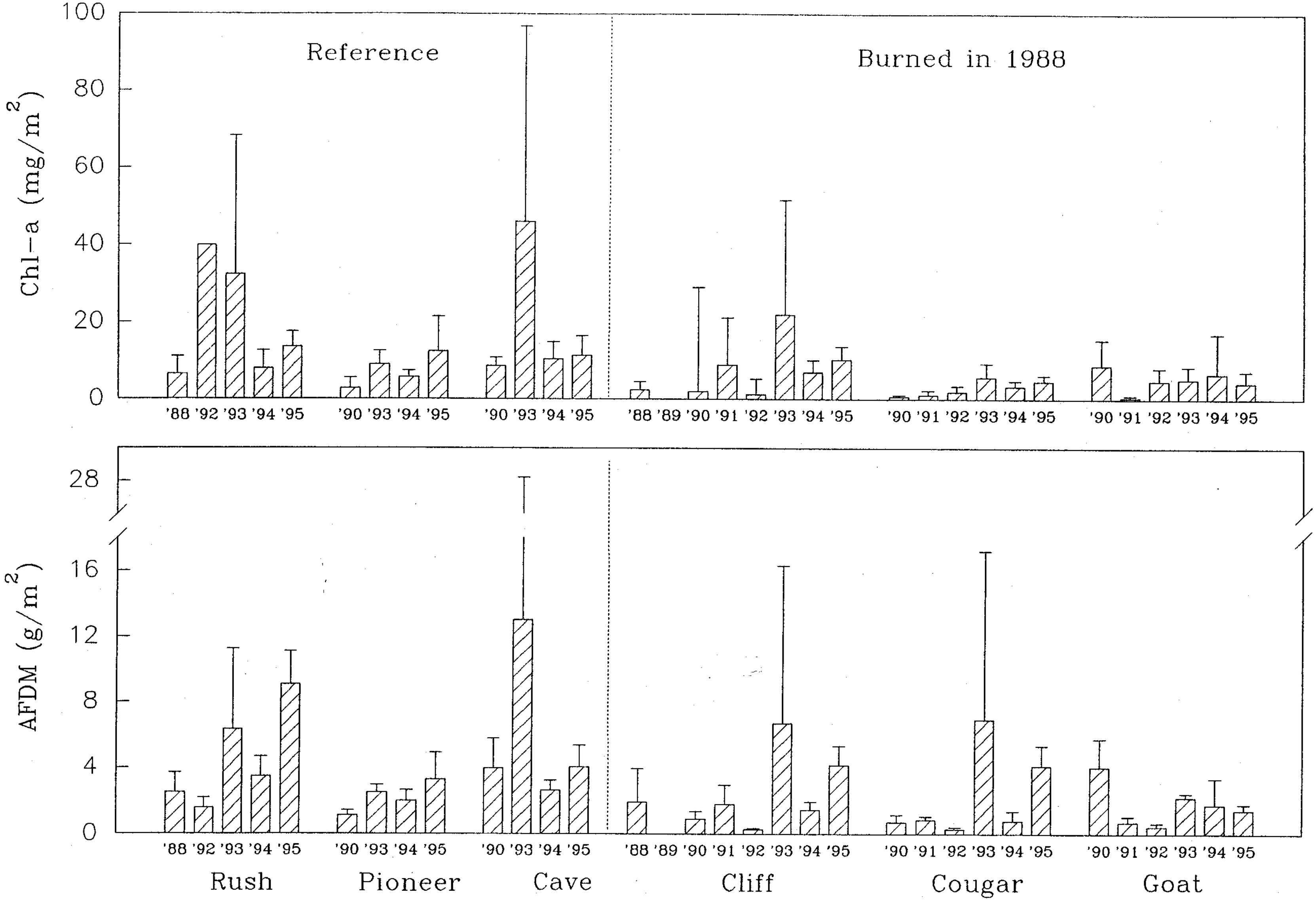


Fig. 5. Mean values of periphyton chlorophyll a and ash-free dry mass (AFDM)for the study streams. Error bars equal +1SD from the mean, n=5.

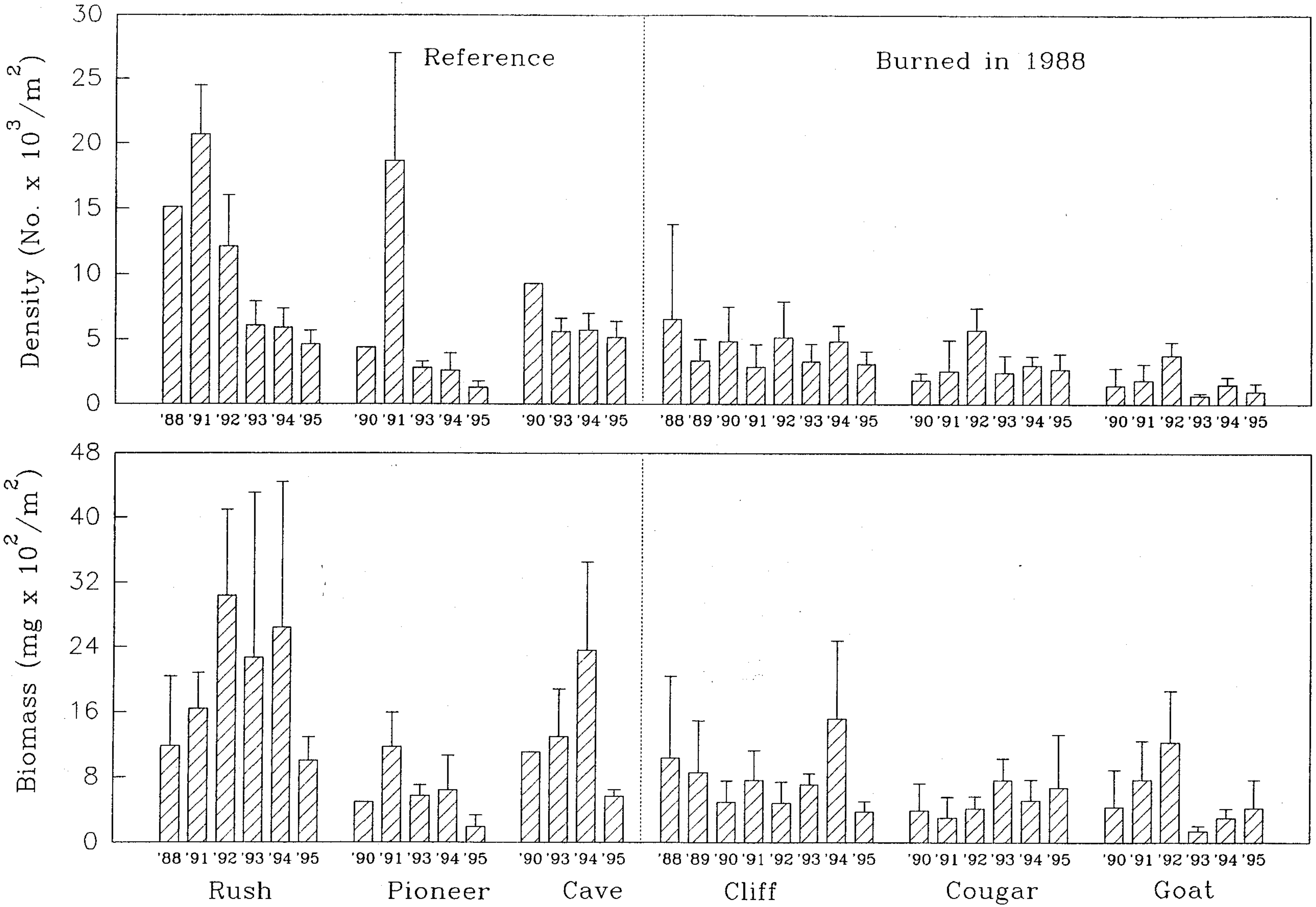


Fig. 6. Mean values of macroinvertebrate density and biomass from the study streams. Error bars equal +1SD from the mean, n=5. Note differences in scale and units on the Y-axes of the graphs.

in the other streams (Fig. 7). As in previous years, the greatest richness value was observed in Rush Creek (29 taxa) and the lowest in Goat Creek (14 taxa). Simpson's Index was lowest in Rush (0.11) and greatest in Goat Creek (0.35), although the variance in Goat was large. In general, Rush Creek appears to be the most diverse and Goat the least diverse system, in terms of aquatic macroinvertebrates. Of the streams examined, Rush is the largest and Goat the smallest; stream size may be at least partly responsible for the differences in diversity (Minshall et al. 1985).

As with total taxa richness, richness of EPT taxa was lowest in Goat Creek (6-10 taxa) (Fig. 8). Community dominance (i.e., relative abundance of the most common taxa) ranged from ca. 0.2 - 0.5 among all streams from 1993-95. Rush, Cave, and Goat have all displayed a consistent increase in the abundance of Oligochaeta from 1993-95, although in general Cliff appears to contain the most Oligochaeta (Fig. 9). The abundance of Chironomidae was variable both among streams and between years within a stream. This may be a result of among-year differences in the time of sampling (i.e., just before versus just after emergence of a cohort), or the patchy distribution of these organisms in the stream. The relative abundance of filterers was low among all sites and years (<0.2), as expected in headwater mountain streams (sensu Vannote et al. 1980). The relative abundance of scrapers did not exhibit any distinct pattern, but was less than 0.4 for all streams from 1993-95.

PCA was used to analyze all the streams, years, and metrics. Figure 10 shows the results from the PCA, with Factor 1 (x-axis) showing increasing diversity and Factor 2 (y-axis) indicating increasing abundance. The individual variables that contributed to the factors are shown in parentheses. The + or - sign indicates the direction of change in the variable. Cliff and Cougar displayed much less year-to-year variation than did Cave, Rush, or Pioneer. For the years examined, Goat Creek showed

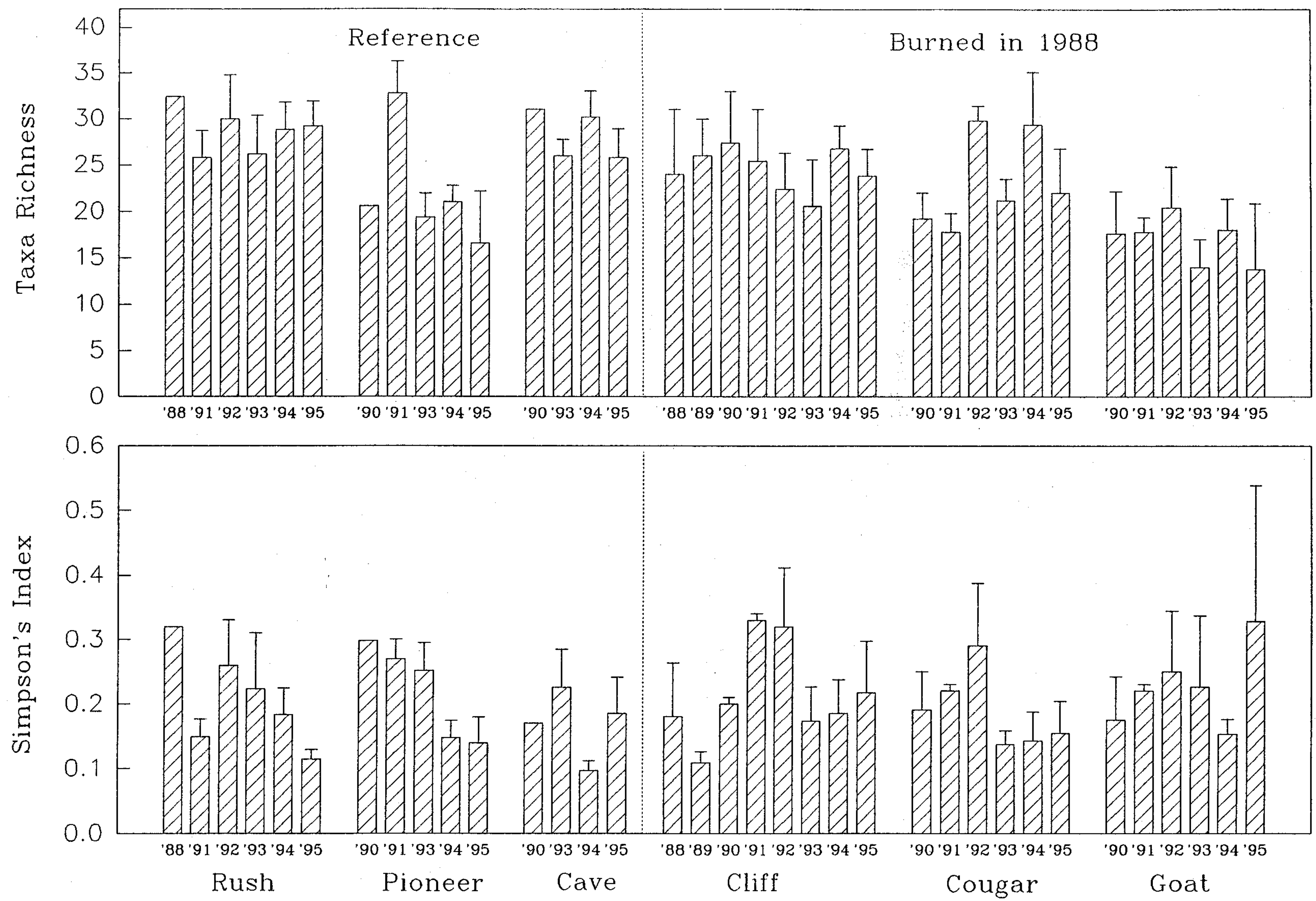


Fig. 7. Mean values of macroinvertebrate taxa richness and Simpson's Index from the study streams. Error bars equal +1SD from the mean, n=5.

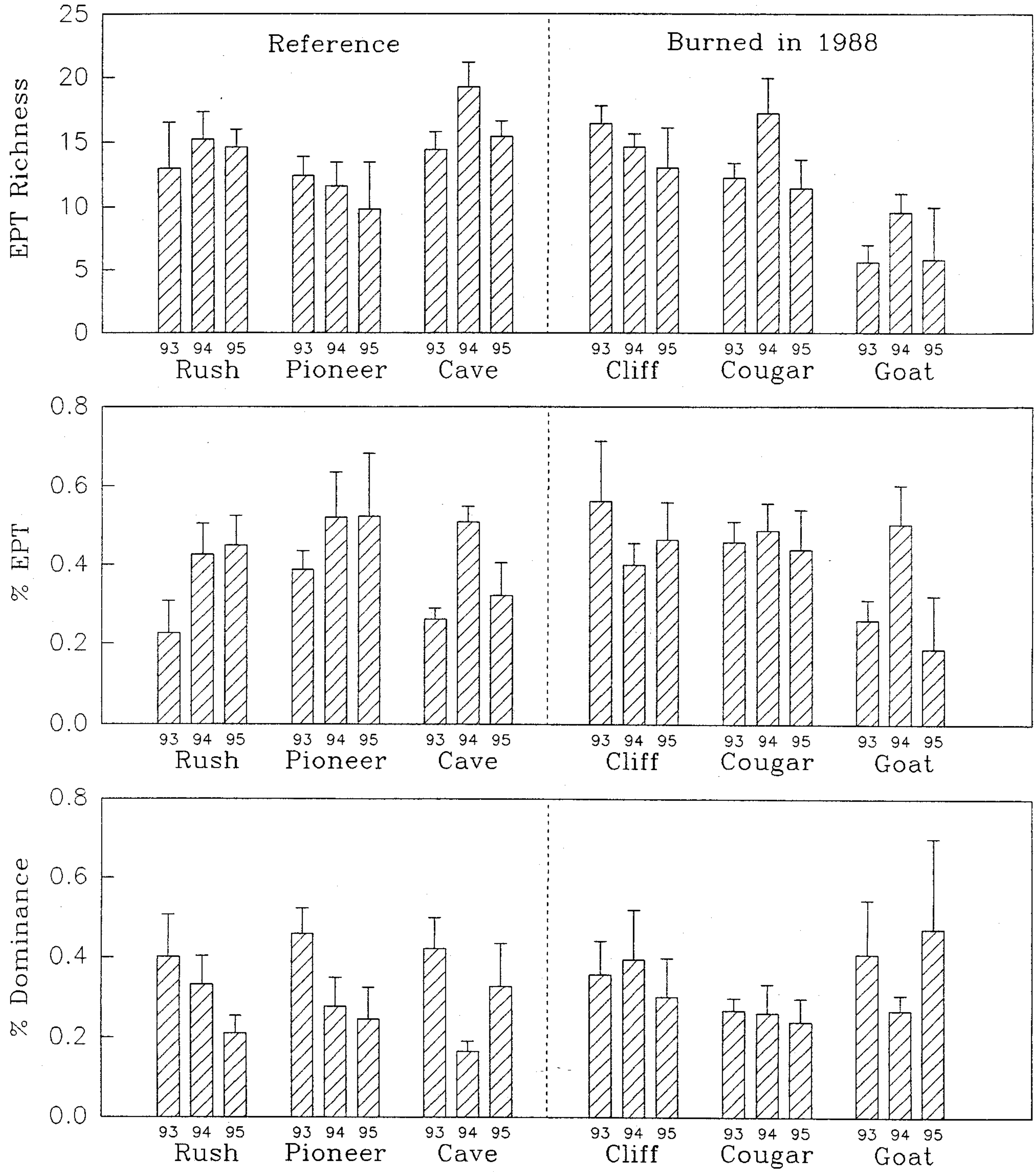


Fig. 8. Richness of EPT taxa, % of the community consisting of EPT taxa, and % dominance of the community for the study streams from 1993–1995. Error bars equal +1SD from the mean, n=5.

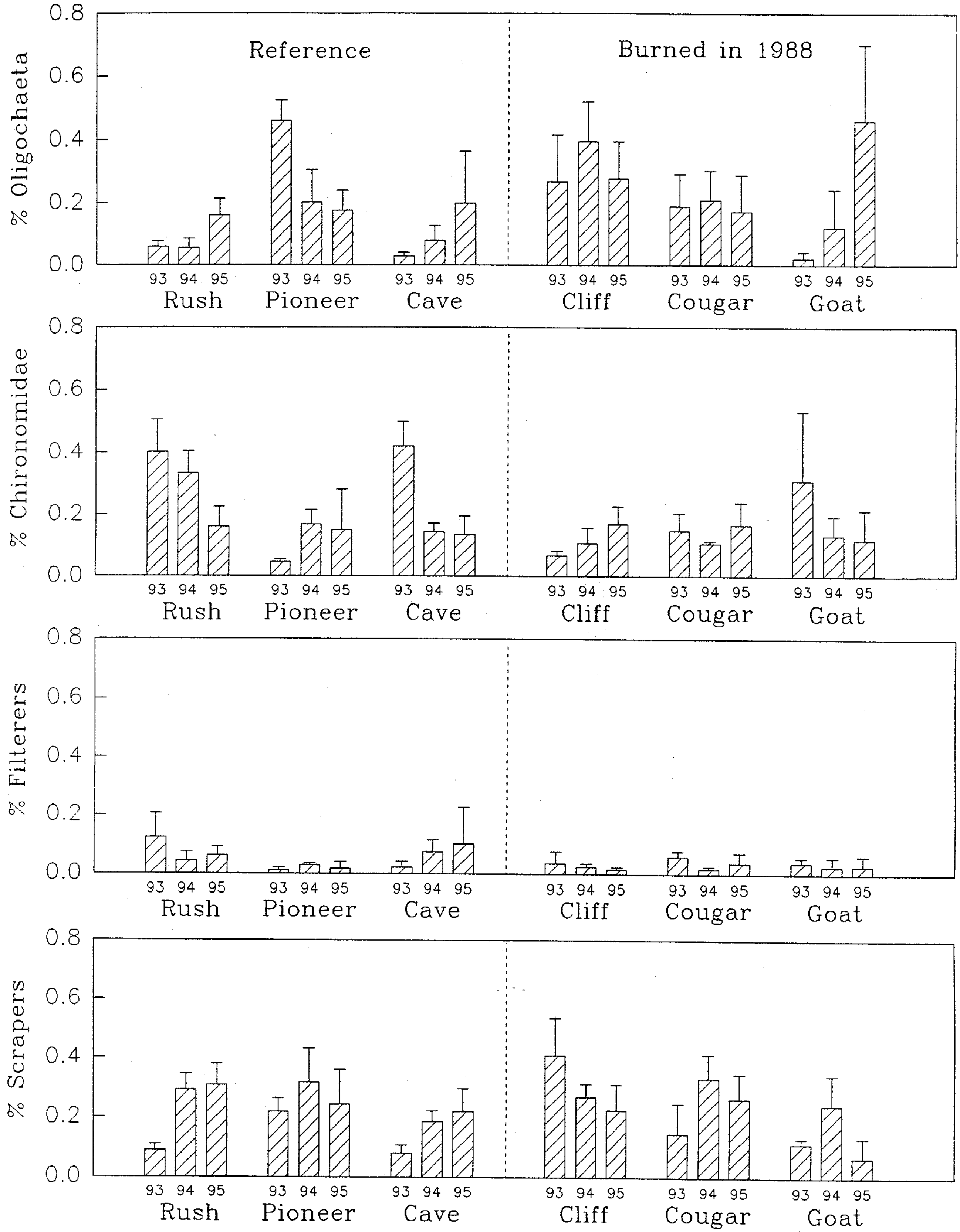


Fig. 9. Mean abundance of the groups Oligochaeta and Chironomidae and the functional feeding groups filterers and scrapers. Error bars equal +1SD from the mean, n=5.

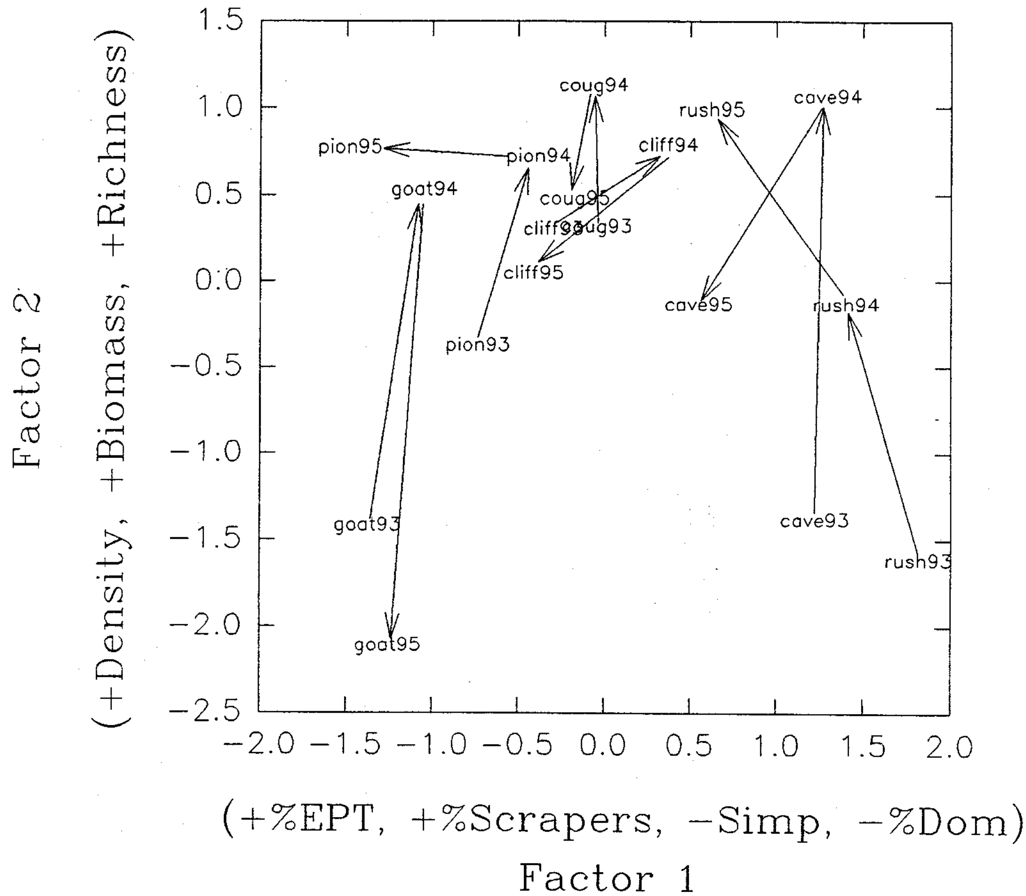


Fig. 10. Scatterplot of PCA results for the study streams from 1993–1995. The first two factors explained 71% of the variance. Arrows indicate time progression. See text for explanation of axis labels.

little variation on Factor 1, but considerable changes in Factor 2. In general, the reference streams displayed more variation in these variables than did Cliff or Cougar Creeks. Furthermore, the reference streams all appeared to vary in a consistent manner (moving up and to the left over time in Fig. 10), suggesting similar processes were operating in each reference stream.

The relative abundances of the 15 most common macroinvertebrate taxa found in 1995 are presented for each stream in Table 5. As in 1994, the most common taxa in 1995 were Chironomidae, Oligochaeta, *Heterlimnius*, and *Baetis bicaudatus*.

Upper and Lower Cliff Creek

Discharge in both Upper (burned) and Lower (unburned) Cliff Creek was approximately two fold greater in 1995 as in 1994 (Table 6). Conductance, alkalinity, and hardness all were greater in Lower Cliff than in Upper Cliff. Mean BOM values were the same in both reaches in 1995. In both 1994 and 1995, periphyton chl *a* values were considerably greater in Lower Cliff than in Upper Cliff. Periphyton AFDM values, however, were nearly identical between the two reaches. Substratum size and embeddedness and stream width also were quite similar among the two reaches (Table 6).

The aquatic macroinvertebrate community was notably different between the burned and unburned portions of Cliff Creek in 1994. However, the patterns observed in 1994 were not consistent with those found in 1995. For example, during 1994 macroinvertebrate density and taxa richness were significantly greater in Upper Cliff, but there was no difference between the reaches in 1995 (Fig. 11). Simpson's Index showed the opposite pattern in 1995 as was seen in 1994. Furthermore, mean biomass was not different in 1994, but in 1995 it was three times as great in Upper Cliff as in Lower Cliff. The relative abundance of functional feeding groups (after Merritt and Cummins 1996)

Table 5. Relative abundance of the 15 most common macroinvertebrate taxa found in the study streams during July 1995. SD = one standard deviation from the mean, n=5.

	Rel. Abund. (%)			Rel. Abund. (%)	
Rush Cr.	Mean	SD	Cougar Cr.	Mean	SD
Chironomidae	16.1	6.4	Oligochaeta	17.3	11.7
Oligochaeta	16.0	5.3	Chironomidae	16.6	7.3
Baetis bicaudatus	14.4	3.8	Baetis bicaudatus	13.5	4.4
Cinygmula	9.2	2.9	Heterlimnius	12.9	10.1
Hydracarina	8.5	1.0	Cinygmula	9.8	5.6
Serratella inermis	7.0	1.7	Zapada	9.3	6.2
Epeorus longimanus	6.4	2.1	Parapsyche elis	2.1	2.6
Simulium	5.3	3.2	Suwallia	1.7	1.6
Optioservus	3.8	1.7	Megarcys	1.7	0.6
Hesperoperla pacifica	1.5	0.4	Hydracarina	1.5	1.2
Suwallia	1.4	0.7	Polycentropus	1.3	2.1
Heterlimnius	1.3	0.7	Turbellaria	1.3	1.1
Brachycentrus	0.8	0.8	Lara	1.2	1.9
Oreogoton	0.7	0.4	Simulium	1.1	1.0
Micrasema	0.7	0.5	Dicronota	0.9	0.5
Pioneer Cr.	Mean	SD	Cliff Cr.	Mean	SD
Oligochaeta	17.6	6.3	Oligochaeta	39.4	12.5
Chironomidae	15.0	13.1	Cinygmula	11.0	4.8
Cinygmula	13.2	5.8	Chironomidae	10.8	5.0
Calineuria	10.2	2.6	Baetis bicaudatus	6.7	3.1
Heterlimnius	7.4	4.0	Zapada	4.9	0.8
Suwallia	7.0	3.8	Heterlimnius	4.8	3.4
Baetis bicaudatus	6.8	4.6	Epeorus longimanus	4.7	0.9
Zapada	6.3	6.4	Drunella doddsi	2.8	1.4
Hydracarina	2.9	1.8	Suwallia	2.6	1.0
Epeorus longimanus	2.5	1.8	Simulium	1.6	0.9
Polycentropus	2.4	1.0	Doliphilodes	1.4	1.1
Simulium	1.5	1.9	Drunella coloradensis	1.3	1.4
Turbellaria	1.4	1.9	Hydracarina	1.2	0.7
Neothremma	1.0	1.6	Polycentropus	0.9	0.8
Micrasema	0.8	0.9	Serratella inermis	0.8	0.5
Goat Cr.	Mean	SD	Cave Cr.	Mean	SD
Oligochaeta	45.9	24.2	Oligochaeta	19.9	16.3
Heterlimnius	12.1	6.4	Baetis bicaudatus	16.7	7.5
Chironomidae	11.8	9.5	Heterlimnius	14.3	8.4
Zapada	8.0	4.2	Chironomidae	13.5	6.1
Simulium	2.9	3.3	Simulium	10.1	12.5
Drunella coloradensis	2.8	4.2	Hydracarina	7.4	2.4
Cinygmula	2.0	1.3	Calineuria	3.1	0.9
Curculionidae	1.8	3.6	Cinygmula	2.0	0.9
Baetis bicaudatus	1.4	1.4	Epeorus longimanus	1.8	1.0
Suwallia	1.3	1.1	Serratella inermis	1.5	1.2
Collembola	1.3	1.8	Skwala	1.4	1.0
Turbellaria	1.2	0.7	Micrasema	1.0	0.5
Rhyacophila acropedes	1.1	1.2	Glutops	1.0	0.8
Hydracarina	1.0	1.3	Doliphilodes	0.6	0.7
Dixa	0.8	1.0	Suwallia	0.5	0.5

Table 6. Benthic habitat variables measured in Upper and Lower Cliff Creek in August 1994 and July 1995. SD = standard deviation.

	Upper Cliff (burned)		Lower Cliff (unburned)	
Q (m3/s)				
1994	0.06		0.09	
1995	0.14		0.15	
Specific Cond. (uS/cm @ 20C)				
1994	47		98	
1995	--		93	
Alkalinity (mg CaCO3/L)				
1995	16		34	
Hardness (mg CaCO3/L)				
1995	40		53	
	mean	SD	mean	SD
BOM (g AFDM/m2)				
1994	14.9	12.0	40.1	28.3
1995	30.8	25.2	29.7	4.9
Periphyton Chl-a (mg/m2)				
1994	3.2	0.9	6.3	4.6
1995	0.7	0.5	10.3	3.3
Periphyton AFDM (g/m2)				
1994	1.4	0.4	2.1	0.6
1995	4.0	3.9	4.2	1.2
Substrata Size (cm)				
1994	21	14	19	16
1995	26	28	22	24
Substrata Embeddedness (%)				
1994	37	25	41	31
1995	73	96	66	73
Stream Width (cm)				
1994	273	166	201	64
1995	440	70	350	70

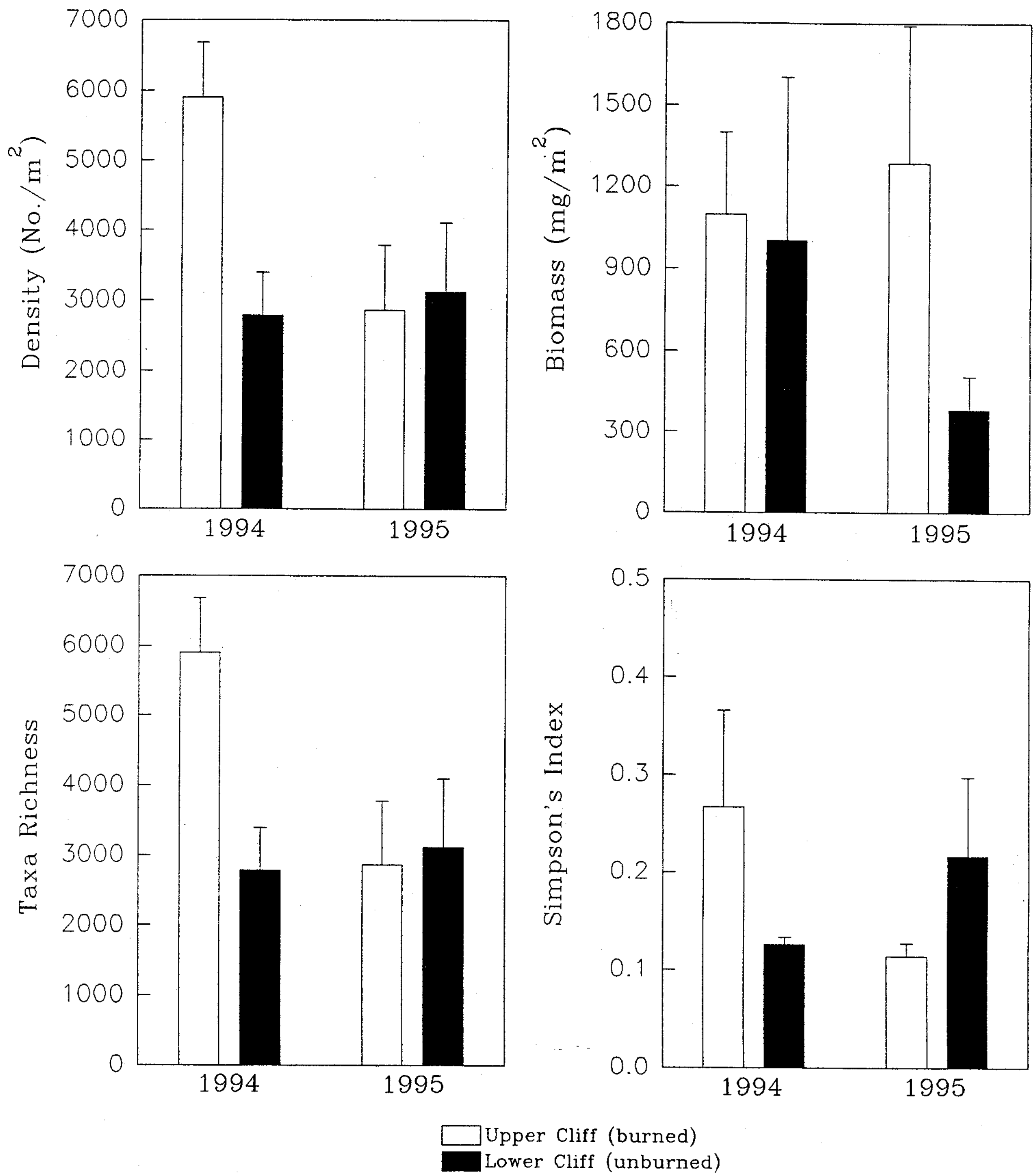


Fig. 11. Mean values of density, biomass, taxa richness, and Simpson's Index for the macroinvertebrate communities in Upper and Lower Cliff Creek during August 1994 and July 1995. Error bars equal +1SD from the mean, n=5.

also displayed disparate patterns among years (Fig. 12). The exception here was seen in the abundance of gatherers and filterers, which were both greater in Lower Cliff in both years. Predators represented a significantly greater proportion of the macroinvertebrate community in the unburned reach than in the burned reach in 1994; the opposite was seen in 1995. The relative abundances of the 15 most common macroinvertebrate taxa in each reach are presented in Table 7. Oligochaeta, Chironomidae, and *Baetis* were consistently among the most abundant taxa in both years.

The two reaches displayed different patterns in retention of CPOM (Fig. 13). The majority of the leaf analogs released in Upper Cliff were retained within the first 30 meters, with the first 10 m containing the greatest percentage. In Lower Cliff, the greatest percentage was in the 31-40 m section. It appeared that a given leaf would travel further in Lower Cliff before being retained than it would in Upper Cliff. There also were differences between the two reaches in the importance of various retention devices. In both reaches woody debris accounted for the majority of the retention (Fig. 14), although it was of greater importance in Upper Cliff. The importance of slack water and cobbles was approximately equal between the reaches. Riparian vegetation was responsible for 8.1% of the retention observed in Lower Cliff, but (although present) provided no retention in Upper Cliff.

South Fork of the Salmon R. Tributaries

Our examination of the Pidgeon and Fritser Creek catchments revealed only small areas of intense wildfire impact. The riparian zones of both streams were relatively undamaged from the Chicken Fire and the channels did not appear unstable. For these reasons we did not expect to detect changes in the biota of Pidgeon Creek (pre-fire data is not available for Fritser).

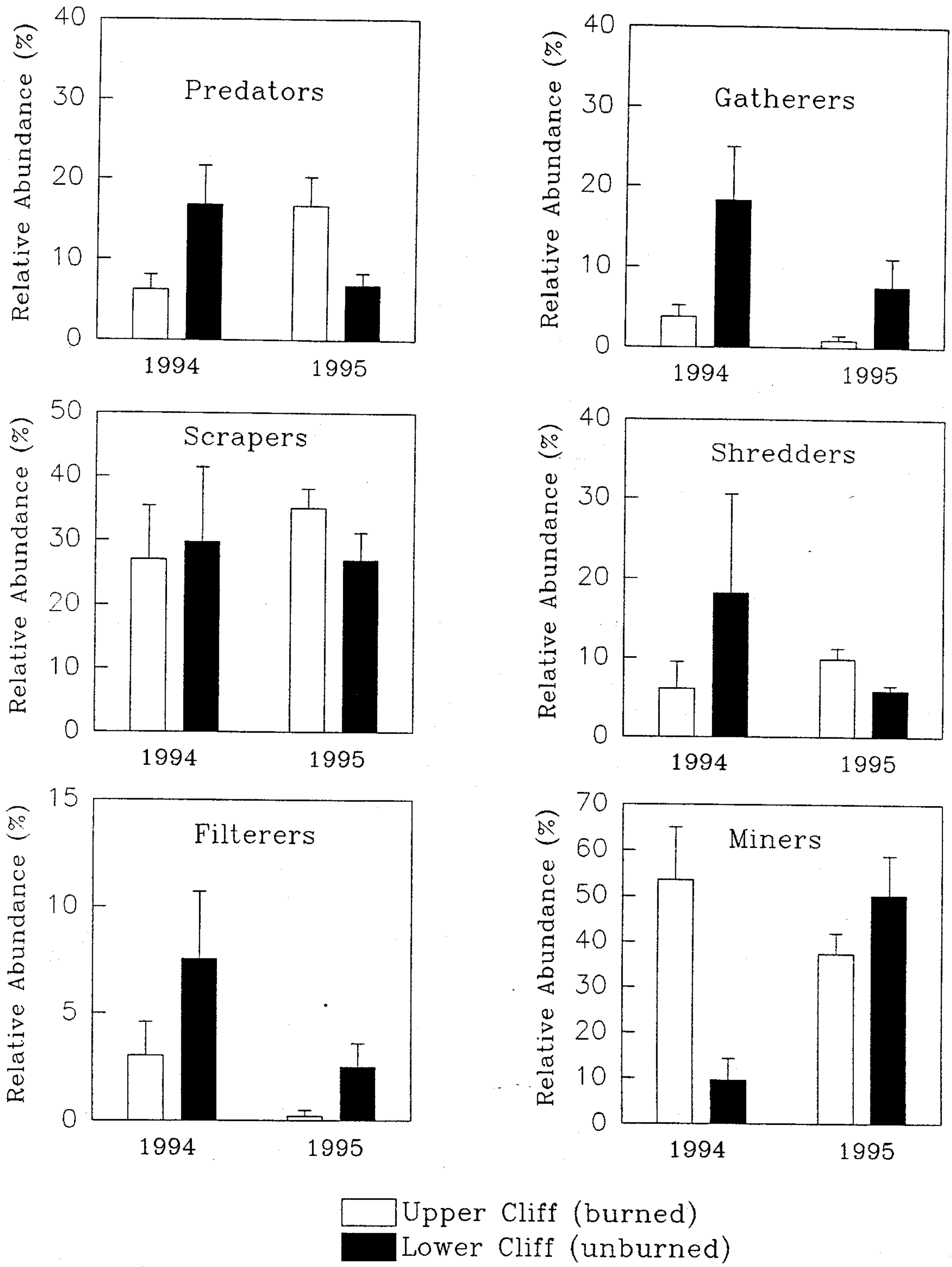


Fig. 12. Mean relative abundance of the various functional feeding groups in Upper and Lower Cliff Creek during August 1994 and July 1995. Error bars equal +1SD from the mean, n=5.

Table 7. Relative abundance of the 15 most common macroinvertebrate taxa in Upper and Lower Cliff Creek in July 1994 and 1995. Mean is based on 5 samples, SD = standard deviation.

	Relative Abundance (%)			Relative Abundance (%)	
Upper Cliff (burned) - 1994	Mean	SD	Upper Cliff (burned) - 1995	Mean	SD
Oligochaeta	46.7	11.8	Chironomidae	21.7	4.7
Baetis bicaudatus	12.7	5.0	Oligochaeta	15.7	5.6
Chironomidae	6.9	1.0	Epeorus deceptivus	8.3	3.1
Neothremma	5.0	3.4	Baetis bicaudatus	8.1	1.8
Yoroperla brevis	3.4	1.3	Yoroperla brevis	5.6	2.8
Glossosoma	3.4	1.1	Drunella doddsi	5.4	2.7
Arctopsyche	2.6	1.4	Polycentropus	5.3	3.4
Serratella tibialis	2.4	1.9	Drunella coloradensis	5.1	1.8
Zapada	2.2	1.8	Suwallia sp.	4.1	3.1
Rhyacophila vagrita	1.5	0.7	Neothremma	3.3	2.2
Turbellaria	1.5	1.2	Cinygmula	3.2	1.7
Cinygmula	1.3	1.2	Megarcys	2.1	0.8
Drunella coloradensis	1.1	0.7	Paraleuctra	2.0	1.7
Rhithrogena robusta	1.0	1.6	Zapada	1.5	1.3
Epeorus longimanus	1.0	1.2	Rhyacophila vagrita	0.8	1.1
Lower Cliff (unburned) - 1994	Mean	SD	Lower Cliff (unburned) - 1995	Mean	SD
Zapada	17.0	12.1	Oligochaeta	39.4	12.5
Baetis bicaudatus	11.9	4.9	Cinygmula	11.0	4.8
Megarcys	11.3	6.6	Chironomidae	10.8	5.0
Heterlimnius	10.2	6.8	Baetis bicaudatus	6.7	3.1
Chironomidae	7.7	6.0	Zapada	4.9	0.8
Parapsyche elsis	7.2	3.0	Heterlimnius	4.8	3.4
Epeorus longimanus	4.8	4.2	Epeorus longimanus	4.7	0.9
Drunella coloradensis	4.7	5.1	Drunella doddsi	2.8	1.4
Cinygmula	4.0	3.7	Suwallia	2.6	1.0
Chelifera	3.2	2.6	Simulium	1.6	0.9
Rhyacophila acropedes	2.5	1.8	Doliphilodes	1.4	1.1
Rhyacophila vagrita	2.0	1.8	Drunella coloradensis	1.3	1.4
Oligochaeta	1.8	1.1	Hydracarina	1.2	0.7
Rhithrogena robusta	1.4	1.7	Polycentropus	0.9	0.8
Neophylax	1.3	2.1	Serratella inermis	0.8	0.5

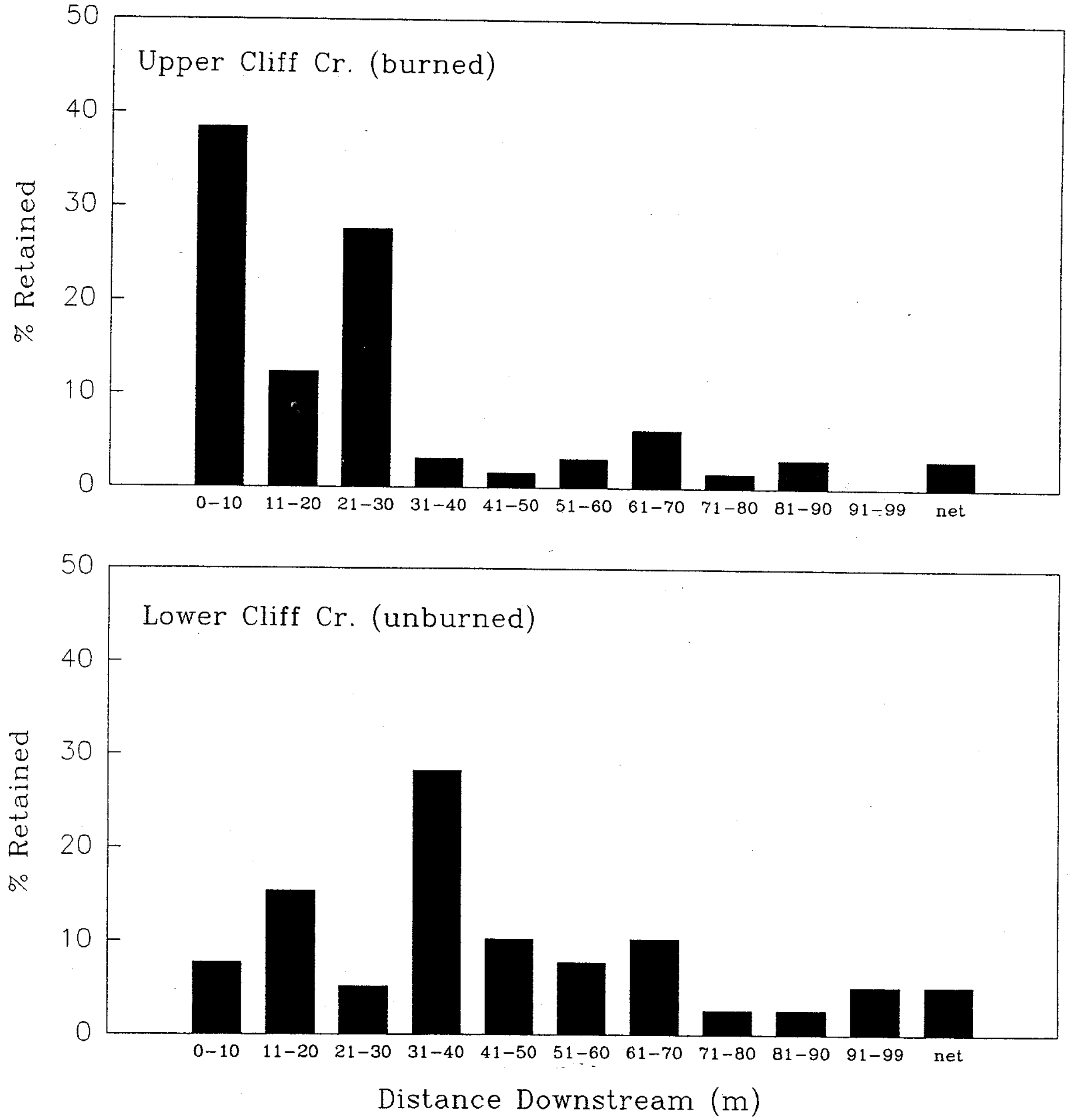


Fig. 13. The distribution of leaf analogs retained in the 100m study reach in Upper and Lower Cliff Creek during July 1995.

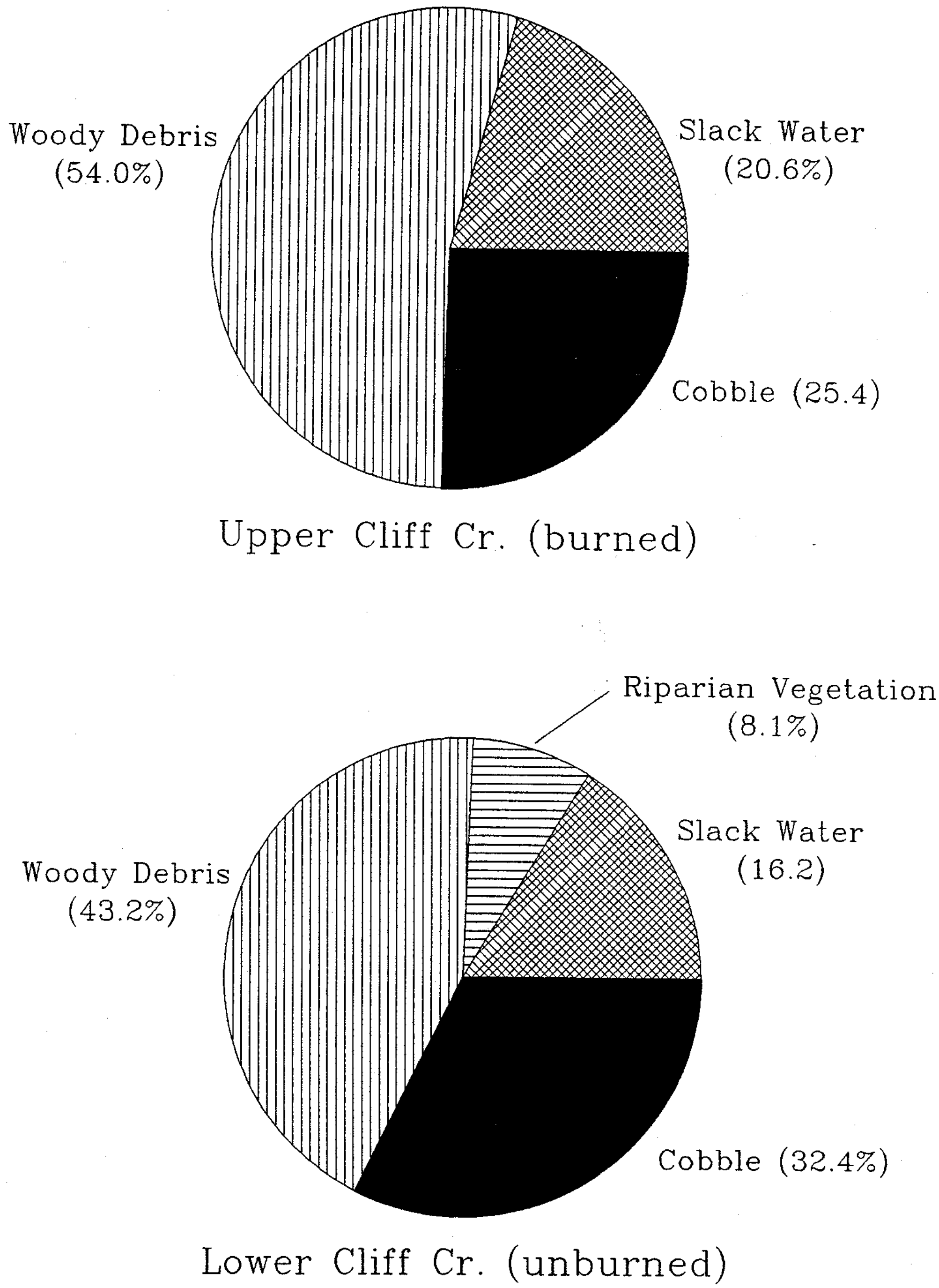


Fig. 14. The relative importance of various CPOM retention devices within the 100m study reaches (i.e., excluding the block net) in Upper and Lower Cliff Creek during July 1995.

Circle End and Tailholt displayed similar substrata characteristics, although Tailholt was approximately 50cm wider and 15cm deeper than Circle End (Table 8). Pidgeon and Fritser were similar to each other in terms of stream size and, in general, approximately twice as large as Circle End and Tailholt. Conductance showed the same spatial pattern in both 1994 and 1995: Circle End > Tailholt > Pidgeon (Fritser was measured only in 1995, but had the lowest conductance of any stream, 23 μS/cm). Alkalinity and hardness were measured only in 1995, but displayed the same pattern as conductance.

Mean values of BOM were similar in 1994 and 1995 for Circle End and Tailholt (Fig. 15). BOM in Pidgeon was greatly reduced in 1995 from that seen 1994, however, the variance in 1994 was large and the mean value was likely an overestimate. In 1995, the greatest mean values of periphyton chl *a* and AFDM were measured in Fritser Creek, although all the streams had similar values. In general, chl *a* ranged from approximately 5-10 mg/m^2 over both years of study, with the exception of Circle End in 1994 (Fig. 15). Indeed, Circle End was the only stream to exhibit a notable change in periphyton standing crop from 1994 to 1995, with a decline in chl *a* and AFDM of 90 and 70%, respectively.

Within each stream, mean values for the macroinvertebrate indices were quite similar in 1994 and 1995 (Fig. 16). Among streams, taxa richness ranged from 16 (Circle End 1995) to 30 (Fritser 1995). As in 1994, mean density was greatest in Tailholt at approximately 7,000 individuals/m^2. For both years, Simpson's Index was less than 0.22 in all streams. Although similar in size, Fritser Creek contained greater macroinvertebrate density, biomass, and taxa richness than did Pidgeon Creek. In Pidgeon Creek, which also was within the burn perimeter of the Chicken Fire, mean density and biomass were slightly greater in 1995 than in 1994, however the variance in these estimates also was notably larger in 1995. The relative

Table 8. Habitat characteristics from the South Fork of the Salmon tributaries. SD = standard deviation, CV = coefficient of variation.

	Circle End	Tailholt	Pidgeon	Fritser
Discharge (m3/s)				
1994	0.009	0.017	0.024	
1995	0.013	0.058	0.164	0.273
Conductance (uS/cm @ 20C)				
1994	160	123	75	
1995	128	93	29	23
Alkalinity (mg CaCO3/L)				
1995	52	30	16	10
Hardness (mg CaCO3/L)				
1995	68	56	28	28

	Circle End			Tailholt			Pidgeon			Fritser		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
Stream Width (cm)												
1994	68	17	0.25	116	22	0.19	184	55	0.30			
1995	117	40	0.34	169	24	0.14	197	29	0.15	283	43	0.15
Stream Depth (cm)												
1994	4	3	0.81	10	5	0.51	12	7	0.62			
1995	5	5	1.13	19	11	0.57	25	13	0.54	26	19	0.74
Substrata Size (cm)												
1994	14	39	2.89	13	30	2.35	7	12	1.68			
1995	30	27	0.89	20	30	1.47	13	19	1.47	42	36	0.84
Substrata Embeddedness (%)												
1994	38	45	1.16	23	33	1.46	76	34	0.45			
1995	64	29	0.46	76	30	0.39	65	38	0.57	55	33	0.60

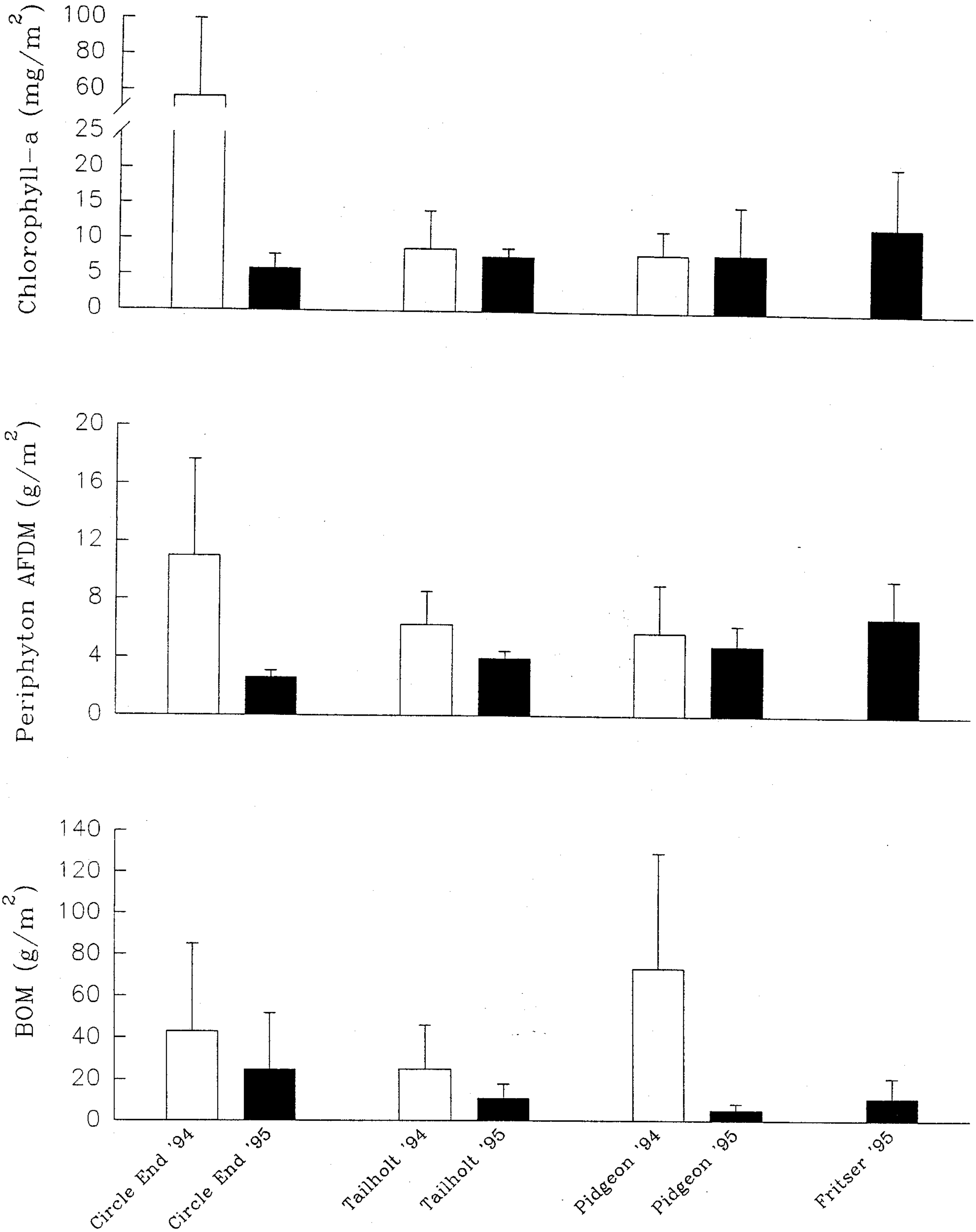


Fig. 15. Mean values of periphyton chl−a and ash−free dry mass (AFDM) and benthic organic matter (BOM) in each stream during Sept. 1994 and July 1995. Error bars equal +1SD, n=5.

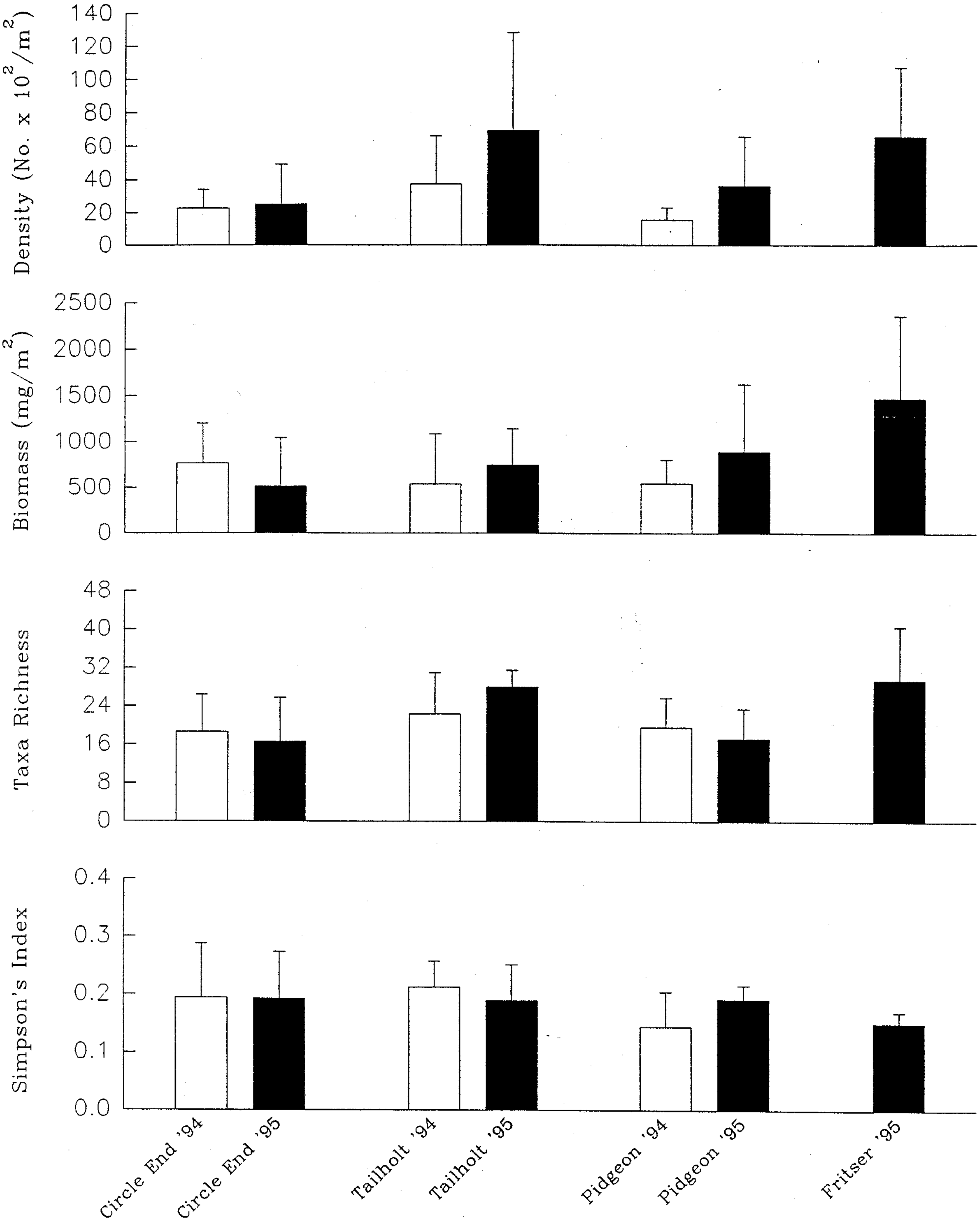


Fig. 16. Mean values of macroinvertebrate density, biomass, richness, and Simpson's Index for each stream in Sept. 1994 and July 1995. Error bars equal +1SD from the mean, n=5.

Table 9. The fifteen most abundant macroinvertebrate taxa from each stream in 1994 and 1995. Mean is based on 5 samples, SD = standard deviation.

Stream/Taxa	Rel. Abund. (%)		Stream/Taxa	Rel. Abund. (%)		Stream/Taxa	Rel. Abund. (%)		Stream/Taxa	Rel. Abund. (%)	
Circle End - 1994	Mean	SD	Circle End - 1995	Mean	SD	Pidgeon - 1994	Mean	SD	Pidgeon - 1995	mean	SD
Yoroperla brevis	21.5	12.8	Chironomidae	17.8	12.4	Heterlimnius	15.7	5.3	Chironomidae	32.5	4.4
Heterlimnius	16.4	9.0	Heterlimnius	15.2	12.7	Yoroperla brevis	14.2	11.9	Optioservus	15.4	6.2
Oligochaeta	15.8	19.0	Yoroperla brevis	12.7	11.1	Baetis bicaudatus	9.9	7.0	Yoroperla brevis	10.8	8.1
Suwallia	14.3	1.8	Oligochaeta	11.3	12.1	Suwallia	9.8	15.4	Suwallia sp.	8.1	10.2
Paraleptophlebia	3.7	4.3	Suwallia	9.4	8.1	Olichochaeta	7.0	3.9	Ostracoda	8.1	5.9
Turbellaria	3.5	2.8	Turbellaria	7.8	10.6	Chironomidae	5.8	3.5	Heterlimnius	4.0	3.1
Hydracarina	3.3	2.6	Optioservus	5.8	6.1	Lara	4.0	3.3	Baetis bicaudatus	3.2	1.3
Chironomidae	2.9	2.7	Rhyacophila vagrita	4.3	2.5	Ostracoda	3.9	7.7	Rhyacophila vagrita	3.2	2.9
Ephemerella inermis	2.1	1.5	Chelifera	2.9	5.5	Capnia	3.8	2.9	Oligochaeta	2.1	1.5
Dicronota	1.9	1.8	Simulium	2.3	2.3	Ephemerella inermis	3.3	2.3	Suwallia	2.1	4.2
Braconidae	1.5	3.1	Zapada	1.2	2.4	Epeorus deceptivus	2.9	4.6	Dicronota	1.7	3.2
Baetis bicaudatus	1.5	1.9	Nematoda	1.2	2.1	Rhyacophila vepulsa	2.8	2.7	Drunella coloradensis	1.5	1.4
Capnia	1.4	1.3	Ostracoda	1.1	1.3	Dicronota	2.6	2.3	Simulium	1.5	1.3
Skwala	1.4	2.1	Lara	0.9	1.2	Zapada	2.2	1.5	Cinygmula	0.7	0.9
Zapada	1.2	1.8	Narpus	0.8	1.1	Hydracarina	1.7	1.8	Caudatella	0.7	1.0
Tailholt - 1994	Mean	SD	Tailholt - 1995	Mean	SD	Fritser - 1995	Mean	SD			
Heterlimnius	24.9	12.5	Chironomidae	22.4	10.0	Chironomidae	24.8	6.5			
Oligochaeta	23.6	16.3	Optioservus	20.8	11.7	Optioservus	13.4	7.6			
Ephemerella inermis	11.4	12.9	Oligochaeta	19.6	14.4	Baetis bicaudatus	10.6	4.6			
Suwallia	7.2	6.0	Baetis bicaudatus	5.3	1.5	Heterlimnius	8.8	10.8			
Chironomidae	3.9	3.7	Yoroperla brevis	5.1	2.2	Baetis tricaudatus	6.6	8.6			
Yoroperla brevis	3.0	0.9	Heterlimnius	4.4	2.3	Oligochaeta	6.4	3.8			
Baetis bicaudus	2.4	2.2	Suwallia	2.5	0.9	Drunella coloradensis	3.3	3.3			
Turbellaria	2.4	2.5	Drunella coloradensis	1.7	2.0	Hydracarina	3.3	1.1			
Isoperla	2.3	2.3	Rhyacophila vagrita	1.7	1.2	Zapada	3.0	3.3			
Dicronota	1.9	3.8	Serratella inermis	1.5	0.7	Micrasema	3.0	1.9			
Hydracarina	1.9	1.1	Turbellaria	1.4	0.8	Turbellaria	2.3	1.8			
Paraleptophlebia	1.8	2.7	Neothremma	1.1	0.9	Yoroperla brevis	1.4	0.8			
Capnia	1.8	1.9	Zapada	1.1	0.6	Caudatella	1.2	1.4			
Rhyacophila angelita	1.3	1.3	Paraleuctra	1.0	1.5	Epeorus longimanus	1.0	1.9			
Neothremma	1.3	1.8	Skwala	0.8	0.7	Suwallia	1.0	0.8			

abundances of the 15 most common macroinvertebrate taxa in each stream are presented in Table 9. As seen in 1994, Chironomidae, *Baetis bicaudatus*, *Heterlimnius*, Oligochaeta, and *Yoroperla brevis* tended to be the most abundant taxa in the streams. *Optioservus*, a small beetle, was not found at the time of sampling in 1994, but was extremely common in 1995. The small stonefly, *Yoroperla brevis*, continued to very abundant in Circle End and Pidgeon Creeks, while absent or at very low density in Tailholt and Fritser Creeks.

DISCUSSION

Water chemistry and in-stream habitat conditions in the Big Creek tributaries have not changed significantly during the course of our research (see Tables 3 and 4). This suggests that in-stream habitat conditions have not yet been affected substantially by the Golden Fire. However, it is likely that the stability of these systems has been reduced by the wildfire and that future disturbances, mainly increased flows, will influence the burned streams to a greater extent than the reference streams (Gurtz and Wallace 1984, Minshall et al. 1995). For example, due to loss of retention by terrestrial vegetation, the burned systems should receive overland runoff at a faster rate than the reference streams and subsequently be scoured more intensively. We plan to examine this hypothesis during the summer of 1996, as intensive flooding has occurred in both the Big Creek and S.F. Salmon catchments from runoff of the 1995-96 snowpack.

The warmer thermal regime observed in Rush Creek, versus Pioneer Creek, is likely due to the larger size and more open canopy of Rush allowing greater solar heating. Early in the year (March - May) and late in the year (October - November) the two streams are nearly identical in temperature. However, during the summer (June - September) Rush is considerably warmer than Pioneer. Canopy shading appears to maintain cooler temperatures in Pioneer. Canopy-opening disturbances (e.g., wildfire, logging) should alter the thermal regime in smaller, forested streams, such as Pioneer, more so than in larger streams, such as Rush. Data collected by the temperature loggers in Upper and Lower Cliff will provide the opportunity to examine the influence of the Golden Fire on the thermal regime of Cliff Creek This may lead to further hypotheses regarding the effects of wildfire on in-stream habitat conditions.

Rush Creek is considerably larger than any of the other streams we sampled in the Big Creek catchment, and has a north facing aspect (see Table 4). Pioneer is similar in size to the burned streams, but also flows in a northerly direction. For these reasons, neither Rush nor Pioneer are likely to be good references for Cliff, Cougar, and Goat in relation to the effects of wildfire. Thus, we used Cave Creek as the reference condition, although the data set for Cave is not as extensive as that for Rush or Pioneer. Using mean values for each year (1990-1995) as replicates, a one-way ANOVA with Tukey HSD was performed to test for differences in density, biomass, richness, and Simpson's Index among Cave, Cliff, Cougar, and Goat. There were no differences (alpha = 0.05) in biomass or Simpson's Index (Appendix A). However, Cave did have significantly greater density than either Cougar or Goat and greater richness than Goat. Interestingly, Cave, Cliff, and Cougar all had significantly greater richness than Goat. However, the differences may be due to the small size of Goat Creek rather than fire, particularly because the fire there was a controlled back-burn, not wildfire.

The patterns observed in macroinvertebrate communities of Upper and Lower Cliff Creek in 1995 were not consistent with those seen in 1994. The influence of discharge may be responsible for the inconsistent results; small spates following precipitation events that did not scour the unburned portion of Cliff may have scoured the bed of the burned portion. Clearly, a longer temporal scale is required in order to distinguish natural variation from wildfire effects. Long-term monitoring provides the baseline data needed to separate natural variation from true disturbance effects. This is true for structural and functional measures, both of which are needed to fully document the influence of a given disturbance on an ecosystem. Functional measures, such as organic matter transport and processing and ecosystem metabolism, integrate conditions of the entire system and often provide greater insight into the dynamics of streams than do structural measures.

Our measure of organic matter transport, using leaf analogs in the burned and unburned portions of Cliff Creek, showed that a particle of CPOM would travel a shorter distance in Upper Cliff than in Lower Cliff; the burned segment was more retentive. This was due to the greater amount of large woody debris in Upper Cliff. We observed that trees killed by the 1988 wildfire had begun to fall into the stream channel, increasing the amount of retention structures in Upper Cliff. Retention of CPOM is hypothesized to decrease following wildfire, as retention structures are scoured away by increased discharge. When trees killed by the wildfire (but left standing) begin to enter the channel, CPOM retention may increase to levels equal to or greater than that present before the wildfire. This may be one of the mechanisms for recovery of the invertebrate communities following wildfire. Thus, salvage logging may severely slow the recovery of stream ecosystems from wildfire by removing the retention devices that ultimately provide channel stability and retain organic matter.

The Chicken Fire did not appear to alter habitat or biotic conditions in Pidgeon Creek. The density and biomass of macroinvertebrates was actually greater following the wildfire. Pre-fire data for Fritser Creek does not exist. However, conditions in Fritser did not appear much different from those of Circle End or Tailholt Creeks. Thus, the immediate influence of the Chicken Fire on both Fritser and Pidgeon appeared to be minimal. However, the high flows that have occurred during the spring of 1996 may have severely altered stream channel and substrata characteristics in these systems. One of the goals in monitoring these streams is to provided baseline data. In this regard, the two years of habitat and biotic data from Tailholt Creek can be used to examine potential influences from unusually high flows and from the experimental logging scheduled for that catchment. Other data, such as amount/quality of leaf litter input, CPOM retention, and dynamics of dissolved organic carbon also would be insightful in documenting the effects of the experimental logging.

In general, diversity of the invertebrate communities was slightly greater in the Big Creek streams than the S.F. Salmon tributaries. Taxa richness ranged from approx. 20-30 in the Big Creek streams and 16-25 in the S.F. Salmon sites. However, the temporal scale of our sampling is much less in the S.F. Salmon catchment than in Big Creek (2 versus 8 years, respectively). These values of taxa richness are similar to those reported for streams recovering from wildfire along the Middle Fork of the Salmon River (Richards and Minshall 1992) and in Yellowstone National Park (Minshall et al. 1995). The same invertebrate taxa tended to predominate in both catchments, namely Chironomidae, Oligochaeta, *Heterlimnius*, and *Baetis*. Other taxa appeared more abundant in one catchment or the other. For example, *Cinygmula* was common in the Big Creek streams, but appeared rarely in the S.F. Salmon tributaries. *Yoroperla brevis* displayed the opposite pattern, occurring commonly in the S.F. Salmon tributaries but rarely in the Big Creek sites.

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Appendix A. Pairwise comparison probabilities from one way ANOVA with Tukey HSD.

Density

	Cave	Cliff	Cougar	Goat
Cave	1.000			
Cliff	0.304	1.000		
Cougar	0.034	0.541	1.000	
Goat	<0.001	0.003	0.057	1.000

Biomass

	Cave	Cliff	Cougar	Goat
Cave	1.000			
Cliff	0.318	1.000		
Cougar	0.103	0.804	1.000	
Goat	0.062	0.634	0.990	1.000

Richness

	Cave	Cliff	Cougar	Goat
Cave	1.000			
Cliff	0.473	1.000		
Cougar	0.190	0.895	1.000	
Goat	0.001	0.004	0.016	1.000

Simpson's Index

	Cave	Cliff	Cougar	Goat
Cave	1.000			
Cliff	0.344	1.000		
Cougar	0.958	0.539	1.000	
Goat	0.499	0.988	0.730	1.000